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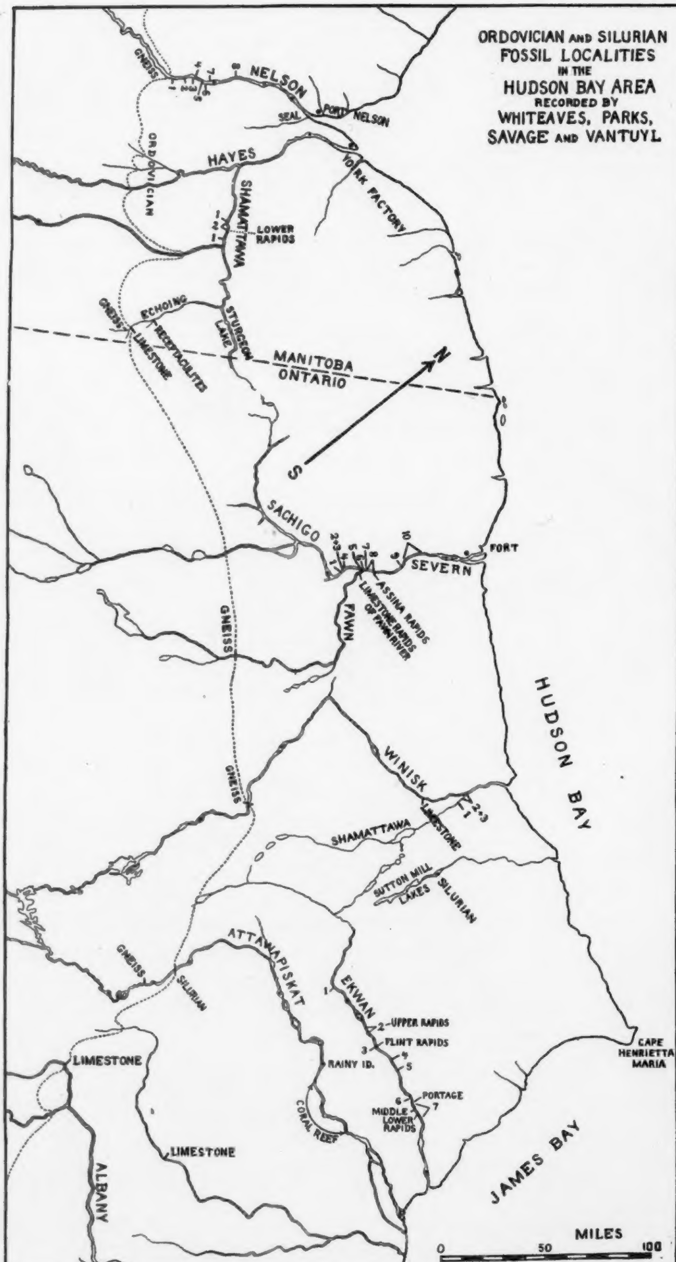
ORDOVICIAN AND SILURIAN FOSSIL LOCALITIES IN THE HUDSON BAY AREA RECORDED BY WHITEAVES, PARKS, SAVAGE AND VANTUYL
NELSON
PORT NELSON
SEAL
GNEISS
ORDOVICIAN
HAYES
YORK FACTORY
SHAMATTAWA
LOWER RAPIDS
ECHOING
STURGEON LAKE
RECEPTACULITES LIMESTONE
MANITOBA
ONTARIO
N
S
SACHIGO
FORT
SEVERN
FAWN
ASSINA RAPIDS
LIMESTONE RAPIDS OF FAWN RIVER
GNEISS
HUDSON BAY
WINISK
LIMESTONE
SHAMATTAWA
SUTTON MILL LAKES
SILURIAN
ATTAWAPISKAT
GNEISS
SILURIAN
EKWAN
UPPER RAPIDS
FLINT RAPIDS
RAINY ID.
PORTAGE
MIDDLE
LOWER RAPIDS
CORAL REEF
LIMESTONE
LIMESTONE
ALBANY
CAPE HENRIETTA MARIA
JAMES BAY
MILES
0
50
100

ORDOVICIAN AND SILURIAN CEPHALOPODS OF THE HUDSON BAY AREA

AUG. F. FOERSTE AND T. E. SAVAGE

Received February 1, 1927, published April 18, 1927

INTRODUCTION AND ACKNOWLEDGMENTS

The southern arm of Hudson Bay, usually known as James Bay, is as far north of Detroit as the distance from Detroit to Boston, and the extension of Hudson Bay from south to north equals the distance from New Orleans to Milwaukee. Devonian, Silurian, and Ordovician strata line the southwestern shore of the bay and extend thence westward from 40 to 80 miles, the Ordovician outcrops being located farther west and the Silurian and Devonian outcrops farther east.

Southwestern Manitoba is occupied by a similar succession of strata, but in reverse order, the Ordovician occupying the full length of Lake Winnipeg, while the Silurian and Devonian outcrop successively farther westward. The intermediate country, varying in width from 70 miles at the north to 160 miles at the south, is occupied by Pre-Cambrian schists, gneisses, and granites, which form an anticlinal axis.

From Lake Winnipeg, the Silurian and Devonian strata continue northwestward, west of the lakes Athabasca, Great Slave, and Great Bear, as far as the Arctic. Ordovician strata have been discovered by Dr. George S. Hume on the west shore of the North Arm of Great Slave Lake.

The Silurian formerly extended northward from the southwest shore of Hudson Bay, across Southampton Island, the Gulf of Boothia, North Devon and Cockburn islands, and Ellesmereland to the northwestern margin of Greenland. Ordovician strata occur at Igloolik island, and on the eastern shore of Ellesmereland, west of the Kane Basin.

The first notable contribution to our knowledge of the Paleontology of the strata lining the southwestern shore of Hudson Bay was made by Whiteaves in 1904, republished in 1906, accompanied by numerous illustrations, in Paleozoic Fossils, vol. 3, pt. 4, Geological Survey of Canada. This report included accounts of the Silurian fossils on the Attawapiskat, Ekwan, Winisk, and Severn rivers, and also on the Sutton Mill Lakes, between the Ekwan and Winisk. No attempt was made, however, to subdivide the Silurian strata into members, nor to determine the exact equivalency of these strata to others farther south. Only 3 new species of cephalopods were described: *Actinoceras keewatinense*, *Orthoceras ekwanense*, and *Phragmoceras lineolatum*.

The second notable contribution to the paleontology of the area bordering on the southwestern shore of Hudson Bay was made in 1912 by Prof. W. A. Parks in a report on the fossils of the Severn, Shamattawa, and Nelson rivers, which was republished, accompanied by illustrations, in 1915 in the Transactions of the Royal Canadian Institute, at Toronto. In this report the exposures on the Shamattawa and Nelson rivers were recognized as Ordovician, and numerous cephalopods were described.

This led to the expedition of Professors Savage and Van Tuyl of the University of Illinois, in 1916, which studied the Ordovician of Nelson and Shamattawa rivers; the Silurian of the Severn, Winisk, and Ekwan; and the Devonian along the Moose and Abitibi rivers. A preliminary report on their investigations was published in 1919 in volume 30 of the Bulletin of the Geological Society of America. In this report the Ordovician and Silurian strata are divided into formations, and the relations of the latter to formations elsewhere are discussed.

Our present studies of the cephalopods of the Hudson Bay area originated with a study of those cephalopods which had been collected in 1916 by Professors Savage and Van Tuyl. However, Prof. W. A. Parks kindly placed at our disposal also those Hudson Bay cephalopods which he had discussed in his reports of 1912 and 1915, and Dr. E. M. Kindle graciously permitted the loan not only of those Hudson Bay specimens which had been

studied by Whiteaves, but also of those collected by A. P. Low in 1904 on the southern half of the west coast of Southampton Island, at the northern margin of Hudson Bay. The material studied includes also a few cephalopods collected by Dr. George S. Hume from the southern part of the west shore of Great Slave Lake, and one collected by Prof. M. Y. Williams eight miles above the entry of the Pagwachuan river into the Kenogami. Finally, Dr. F. A. Bather kindly loaned a number of cephalopods from various localities in Arctic North America, which belong to the British Museum of Natural History. These are illustrated on the accompanying plates, but their discussion is deferred to a later issue of this bulletin. To all of these contributors of material for study the writers of this paper desire to express their full appreciation of the helpfulness and courtesies involved, without which the present contribution would have lost much of its usefulness.

In addition, one of the authors, A. F. Foerste, wishes to acknowledge a grant of one hundred and fifty dollars from the American Association for the Advancement of Science in 1922 in assistance of his studies on these cephalopods.

ORDOVICIAN AND SILURIAN FORMATIONS

In descending order, the Silurian and Ordovician strata of the area southwest of Hudson Bay were divided by Savage and Van Tuyl into the following formations:

- Silurian
  - Attawapiskat
  - Ekwan
  - Severn
  - Port Nelson
- Ordovician
  - Shamattawa
  - Nelson

These formations include distinguishable lithologic units, and a description of these units is here reproduced, using the same system of numbering as that employed by Savage and Van Tuyl

in their report in volume 30 of the Bulletin of the Geological Society of America. By reference to this report it is possible to learn the character of the faunas associated with the different cephalopods here discussed. It will be noticed that no attempt is made here to correlate with each other those subdivisions of the formations which occur along different streams. In the case of each stream, the lowest subdivision exposed, irrespective of the formation to which it belongs, is numbered 1, and the overlying subdivisions are given successively higher numbers. The sections are described in the order of their occurrence on proceeding from the most northern river revealing Ordovician exposures to the most southern river presenting Silurian exposures, among those here discussed.

NELSON RIVER SECTION

	Thickness in feet
Silurian system	
Alexandrian series	
Port Nelson limestone	
8. Dolomite, brown, in regular layers 4 to 10 inches thick, with few fossils; exposed about 4 miles below the Lower Limestone Rapids. The fossils listed are from masses of this dolomite along the bank of the river some distance below the outcrop	28
A gap in exposure	
Ordovician system	
Cincinnatian series	
Shamattawa limestone	
7. Limestone, gray to yellowish brown, exposed in a low arch about 8 miles below the Lower Limestone Rapids	7
A gap in exposure	
6. Limestone, gray, in layers 4 to 14 inches thick, exposed in an escarpment at the Lower Limestone Rapids	28
5. Limestone, gray, passing into one or more layers of yellowish brown dolomite; exposed one-half mile to one mile above the Lower Limestone Rapids	12 to 15
A gap in exposure	
Nelson limestone	
4. Limestone, gray, weathering into irregular layers 1 to 2 inches thick; exposed 1 to 2 miles below the Upper Limestone Rapids	15
3. Dolomite and limestone, gray, mottled with brown fucoidal areas, in layers 12 to 30 inches thick; exposed at the Upper Limestone Rapids	25
2. Limestone and dolomite, gray mottled, in rather thin layers; exposed about 2 miles above the Upper Limestone Rapids	12

A gap in the exposure

1. Dolomite, gray to brown, sandy, grading below into a calcareous sandstone, in rather even layers; exposed about 10 miles above the Upper Limestone Rapids....................................14 to 18

SHAMATTAWA RIVER SECTION

Ordovician system
Cincinnatian series
Shamattawa limestone

2. Limestone, yellowish brown, porous; dolomitic above, mottled gray and brown below, forming the escarpment on the east side of the river at the rapids, and exposed in the upper part of the bluff 1 to 2 miles farther down the river.................................. 23
1. Limestone gray, in rather thin layers, somewhat mottled with brown dolomitized areas; a zone of numerous gasteropods present in the lower part; exposed in both banks of the river 2 or 3 miles below the rapids and also 4 miles above the rapids, where an arch of the strata brings this horizon above the level of the water.......... 15

SEVERN RIVER SECTION

Silurian system
Niagaran series
Attawapiskat coral reef

10. Limestone consisting of separate ridges or domes of structureless limestone composed of stromatoporoid masses, corals and other fossils, ranging from a few to 100 or more feet in diameter and up to 30 or more feet high, with thinly and evenly bedded, fine-grained limestone layers lapping up on the flanks of the domes and ridges, from which they dip away at angles of 20 to 30 degrees, but become nearly horizontal at a distance from them; exposed at Limestone Island and at Long Portage, about 10 miles farther down the river...75 to 85

A short gap in exposure
Ekwan limestone

9. Limestone, yellowish gray, non-dolomitic, in thin regular layers, containing *Trimerella;* exposed in an arch in the north bank of the river 1 to 2 miles above Limestone Island..............About 40

A short gap in exposure

8. Limestone, gray, fine grained, thin bedded, with nodules and bands of chert in some places; containing stromatoporoids; exposed at the first rapids below the mouth of the Fawn River............. 15
7. Limestone, gray, dense, fine grained, thin bedded, with concretions and bands of chert in some places, and an 8-foot ledge of dolomite in the lower part; exposed a short distance above the first rapids below the mouth of the Fawn River.............................. 20
6. Limestone, mostly non-dolomitized, in rather regular layers, brachiopods common in lower part and corals and stromatoporoids more

abundant in the upper; exposed in an arch near the mouth of the Fawn River........ 25

A gap in exposure

Alexandrian series

Severn limestone

5. Limestone, gray, fine grained, in rather even layers, with numerous ostracods in zone near top; exposed about one mile above mouth of Fawn river........ 35
4. Limestone, gray, thin bedded; exposed about 1 mile below first rapids encountered on descending the river........ 4
3. Dolomite, brown, structureless, vesicular, without fossils; exposed in bluff at foot of upper or first limestone rapids encountered on descending the river........ 8
2. Ledge of gray, dense, irregularly bedded, undulating and domed limestone, in layers 2 to 5 feet thick, composed largely of stromatoporoid masses, alternating with zones of fine-grained, thin-bedded limestone 2.5 to 3.5 feet thick; exposed at the upper limestone rapids........ 20
1. Limestone and dolomite, brown, fine grained, imperfectly bedded, with few fossils, showing one or two bands of stromatoporoid structure; exposed on west side of a small island one-half mile above the upper or first limestone rapids on descending the river........ 8

WINISK RIVER SECTION

Silurian system

Alexandrian series

Severn limestone

3. Limestone, rather fine grained, gray, with occasional layers of buff, dolomitic limestone containing few fossils; exposed in bank of Winisk river below the mouth of the Shamattawa and in upper part of bluffs bordering on the Shamattawa........ 25
2. Limestone, gray, fine grained, with many rounded masses showing concentric structure resembling stromatoporoids; exposed in lower part of bluff near mouth of Shamattawa river and in lower part of ledge for 2 miles along the Winisk river below mouth of the Shamattawa........ 12
1. Limestone, gray, fine grained, thin bedded, with few fossils; exposed near base of bluff a short distance above mouth of Shamattawa river........ 8

EKWAN RIVER SECTION

Silurian system

Niagaran series

Attawapiskat coral reef

7. Limestone coral reef, consisting of domes and ridges of stromatoporoids and coral rock, the flanks of which are bordered by layers of fine-grained limestone similar in character to the reef rock ex-

posed on Limestone Island and at the portage farther down the Severn river, with which horizon it corresponds; exposed at portage at Strong Rapids and for several miles below the portage... 30

6. Limestone, composed largely of coral reef rock between the domes and ridges of which layers of fine-grained, thin-bedded limestone are inclined at various angles; exposed at portage at Strong rapids and at rapids 1 mile above the portage.......................... 24

Ekwan limestone

5. Limestone, gray, fine grained, thinly and irregularly stratified; exposed 7 miles below Flint Rapids and about 1 mile farther down the river, where a small anticline appears in the river bank......... 25

4. Limestone, gray, fine grained, coralline, containing numerous concretions and irregular patches of dark chert and stromatoporoid structures which form domes and irregular masses; exposed in the bed and banks of the river at Flint Rapids..............15 to 20

A short gap in exposure

3. Limestone, gray, cherty in the upper part; exposed in the south bank of the river 1 mile above Flint Rapids, where the strata dip gently downstream...12 to 15

2. Limestone, gray, fine grained, thin bedded, containing *Trimerella ekwanensis* near the base; well exposed in the south bank of the river at the Upper Rapids and at the rapids next below.....15 to 20

A gap in the exposure

1. Limestone, buff, fine grained, dolomitic, in places mud cracked; without fossils; exposed in south bank of river between Matateto and Crooked rivers...6 to 8

ORDOVICIAN LIMESTONES OF SOUTHERN MANITOBA

The Ordovician strata of southern Manitoba apparently may be divided into two major zones: an upper zone known as the Stony Mountain limestone and a lower zone for which the term Winnipeg limestone would be appropriate.

The Stony Mountain limestone is of Richmond age and has a considerable number of species in common with the Richmond of Anticosti, especially with its Vaurial (formerly Charleton) member. The only cephalopod listed so far from this limestone is *Apsidoceras insigne* (Whiteaves).

The Winnipeg limestone includes two horizons, that of East Selkirk and vicinity, and that of the southern part of Lake Winnipeg. Neither of these horizons has any equivalent on Anticosti.

The East Selkirk horizon includes *"Cycloceras" selkirkense* (Whiteaves), *Cyrtogomphoceras magnum* (Whiteaves), *Diestoceras*

nobile (Whiteaves), *Lambeoceras lambi* (Whiteaves), *Narthecoceras crassisiphonatum* (Whiteaves), and "*Trochoceras*" *mccharlesi* Whiteaves. *Narthecoceras crassisiphonatum* and *Diestoceras nobile* are found also at Lower Fort Garry.

The limestone exposed in the southern part of the Lake Winnipeg area, including its islands and shores, includes *Armenoceras richardsoni* (Stokes), *Billingsites costulatum* (Whiteaves), *Charactoceras plicatus* (Whiteaves), *Cyrtogomphoceras intermedium* (Whiteaves), *Cyrtogomphoceras whiteavesi* (Miller), *Diestoceras apertum* (Whiteaves), *Diestoceras* (?) *gracile* (Whiteaves), *Murrayoceras semiplanatum* (Whiteaves), *Narthecoceras simpsoni* (Billings), *Orthoceras winnipegense* (Whiteaves), *Paractinoceras canadense* (Whiteaves), *Plectoceras canadense* (Whiteaves), *Westenoceras manitobense* (Whiteaves), and *Westenoceras* (?) *laticurvatum* (Whiteaves). (For bibliography of these species, see Bassler's Bibliographic Index.)

CORRELATION OF NELSON LIMESTONE

Of the 4 species of cephalopods definitely known to come from the Nelson limestone of the Hudson Bay area, 3 indicate relationship with the Winnipeg limestone of southern Manitoba. *Cyrtogomphoceras nutatum* is related closely to *Cyrtogomphoceras magnum* (Whiteaves) from East Selkirk, and to *Cyrtogomphoceras whiteavesi* (Miller) from Lake Winnipeg. An unidentifiable specimen of *Diestoceras* is similar to *Diestoceras nobile* from East Selkirk and Lower Fort Garry, and to *Diestoceras apertum* from Lake Winnipeg. The third specimen is a much distorted specimen of *Westenoceras*, apparently closely related to *Westenoceras manitobense* from Lake Winnipeg. These three specimens indicate relationship with the Winnipeg limestone, as stated above. The fourth specimen, described here as *Endoceras nelsonense*, is not known to have a close relative in southern Manitoba.

Recently Prof. Gustaf T. Troedsson[1] described from the coast

[1] Troedsson, On the Middle and Upper Ordovician Faunas of Northern Greenland; pt. 1, Cephalopods; 1926; p. 113-4.

east of Cape Calhoun, on the northern shore of Kane Basin, in northwestern Greenland, a rich cephalopod fauna which is remarkable for its close resemblance to that of the Winnipeg limestone in southern Manitoba. This fauna includes

Apsidoceras elegans	Kochoceras cuneiforme
Armenoceras arcticum	Kochoceras cuneiforme robustum
Armenoceras arcticum angustum	Kochoceras ellipticum
Armenoceras concinnum	Kochoceras ellipticum minutum
Calhounoceras candelabrum	Kochoceras undulatum
Charactoceras baeri	Kochoceras productum
Charactoceras rotundum	Lambeoceras princeps
Cyrtogomphoceras curvatum	Lambeoceras nudum
Cyrtogomphoceras turgidum	Lambeoceras magnum
Cyrtogomphoceras sacculus	Lambeoceras boreum
Danoceras ravni	Lambeoceras leveannulatum
Dawsonoceras (?) aquilonare	Narthecoceras inflatum
Diestoceras pyriforme	Sactoceras striatum
Eskimoceras boreale	Sactoceras lineatum
Huronia arctica	

In southern Manitoba, *Apsidoceras* is known only from the Stony Mountain limestone, a Richmond formation; and on Anticosti it occurs in all the divisions of the Richmond. It occurs also in the Shamattawa limestone southwest of Hudson Bay. *Armenoceras* occurs in the Lake Winnipeg horizon, but it occurs also in the Richmond of Anticosti, and is widely distributed in the Silurian. *Charactoceras* is present in the Lake Winnipeg horizon, but it occurs also in the Richmond of Anticosti, Illinois, Indiana, and Ohio. *Cyrtogomphoceras* is known from both the Lake Winnipeg and East Selkirk horizons of the Winnipeg limestone, and it occurs also in the Nelson limestone. *Diestoceras* also occurs at both horizons in the Winnipeg limestone; a specimen was found in the Nelson limestone; but it occurs also in the Richmond of Anticosti, Indiana, and Ohio. *Huronia*, somewhat similar to *Huronia septata* was found loose at the mouth of the Red River, probably from the Winnipeg limestone; southwest of Hudson Bay it is known only from the Shamattawa limestone, a Richmond formation. *Lambeoceras* occurs in the East Selkirk horizon of the Winnipeg limestone;

but it is known also from the Richmond of Indiana and Ohio.[2] *Narthecoceras* is known from both members of the Winnipeg limestone. *Kochoceras* is not known from southern Manitoba, but southwest of Hudson Bay it occurs in the Shamattawa limestone, a Richmond formation.

From the preceding notes it is evident that there is a strong resemblance between the cephalopod fauna here cited from northwestern Greenland and that from the Winnipeg limestone in southern Manitoba; moreover, that a considerable part of the genera found in the Winnipeg limestone continue into strata whose Richmond age is unquestioned, but which are located in other areas. The result is that Troedsson has referred the Greenland cephalopod fauna here discussed to the Richmond, recognizing no difference in stratigraphical distribution in the material submitted to him for study. In the meantime, a similar disposition to refer the Winnipeg limestone fauna to the Richmond obtains in America. It finds expression, in Bassler's Bibliographic Index of American Ordovician and Silurian Fossils, in the reference of numerous species from this Winnipeg limestone to a horizon doubtfully identified as Black River or Richmond. On page 1458 of the work cited Bassler listed the fossils from the strata called the Winnipeg limestone in the present publication. Regarding this list Bassler stated: "This list includes the species from the Cat Head (in Lake Winnipeg) and associated formations in Manitoba. Although recorded as of Mohawkian age by Whiteaves, it is probable that many of them were derived from Richmond strata."

The studies of Savage and Van Tuyl[3] on the Ordovician of the area southwest of Hudson Bay indicated that 2 horizons there were identifiable, of which the upper, known as the Shamattawa limestone, corresponded to the Stony Mountain limestone of Manitoba, and unquestionably is of Richmond age, while the lower horizon, called the Nelson limestone, corresponds to those

[2] Foerste, Notes on Richmond and related Fossils. Jour. Cincinnati Soc. Nat. Hist., vol. 22, 1917; p. 44.

[3] Savage and VanTuyl, Geology and Stratigraphy of the area of Paleozoic Rocks in the vicinity of Hudson and James Bays; 1919; p. 341.

strata in southern Manitoba here called the Winnipeg limestone. This lower limestone is characterized by the presence of *Receptaculites oweni* and of the peculiar cephalopods that find such wonderfully similar representatives on the northwestern coast of Greenland; moreover, it is this lower limestone, which, according to Bassler, includes species many of which probably are of Richmond age.

In the Hudson Bay area it was evident that several easily identifiable corals of striking character were common to both limestones, the Nelson and Shamattawa. These include *Calapoecia canadensis*, *Columnaria* (*Palaeophyllum*) *stokesi*, and *Halysites gracilis*.

In the Liskeard formation[4] of the Lake Timiskaming area, *Receptaculites oweni*, *Columnaria* (*Palaeophyllum*) *stokesi*, and *Halysites quebecensis* are present. Of these, the species named last appears to be practically identical with *Halysites gracilis* as identified from Richmond strata. In addition there is a *Columnaria alveolata discreta* which probably is closely similar to the form identified as *Columnaria calicina* from Nelson and Shamattawa limestones of the Hudson Bay area. The associated fossils are identified by Dr. George S. Hume with well known Trenton forms. On this account, the presence of *Narthecoceras crassisiphonatum* and *Dunleithoceras cordatum* in the Liskeard formation are of interest, since the *Narthecoceras* is known only from the Winnipeg limestone in southern Manitoba and the *Dunleithoceras* was described from a drift specimen of uncertain horizon on the Nelson river in the area southwest of Hudson Bay. This occurrence in the Liskeard formation suggests that the Hudson Bay specimen belonged to the Nelson limestone.

In the so-called Richmond strata on the northwestern coast of Greenland the genus *Kochoceras* forms a characteritic part of that fauna which finds its nearest relatives in the Winnipeg limestone of southern Manitoba and in the Nelson limestone of the Hudson Bay area. As was to be expected, additional species of this genus occur on the western shore of Kane Basin, on the east coast of Ellesmereland. Among these, *Kochoceras*

[4] Hume, The Palaeozoic Outlier of Lake Timiskaming, Ontario and Quebec; 1925; p. 18.

lenticulare and *Kochoceras fieldeni* are figured in the present paper, and will be described in a subsequent number of the bulletin. *Kochoceras mantelli* is figured here from Igloolik Island, in the strait between Baffin Land and Melville peninsula, about 750 miles west of south from the Kane Basin locality which furnished the species studied by Troedsson. A species of *Kochoceras* was figured by Foord[5] from Igloolik Island, and was doubtfully referred to *Actinoceras bigsbyi.* Another specimen of *Kochoceras* was figured by Foord from Great Slave Lake, under the name *Actinoceras.* Both of the Foord specimens are in the British Museum of Natural History. From Igloolik Island to Nelson River, southwest of Hudson Bay, is an additional distance of 900 miles, and from the mouth of Nelson River to East Selkirk and Lower Fort Garry in southern Manitoba is 500 miles farther south, producing a total of 2150 miles from southern Manitoba to Kane Basin in northwestern Greenland, in a direction only moderately west of south, a distance as great as that from the northeastern corner of Labrador to the southern end of Florida. Great Slave Lake lies west of this line about 700 miles, and it presents a few Ordovician fossils along the western shore of its North Arm. These may correspond approximately to the Ordovician as exposed southwest of Hudson Bay and in southern Manitoba, but no cephalopods characteristic of these regions have been found so far, though the specimen of *Kochoceras* figured by Foord is suggestive.

CORRELATION OF SHAMATTAWA LIMESTONE

The Shamattawa limestone evidently is related closely to the Stony Mountain member of the Richmond in southern Manitoba. In common with the latter it contains such characteristic species as *Streptelasma trilobatum* (Whiteaves), the coarsely striated form of *Dinorthis* which resembles *Dinorthis subquadrata,* and the large and coarse form of *Rhynchotrema* which resembles *Rhynchotrema capax.* It includes also a considerable variety of cephalopods, in contrast with the single species listed so far

[5] Foord, Catalogue of the Fossil Cephalopoda; pt. 1; 1888; p. 165.

from the Stony Mountain limestone, namely *Apsidoceras insigne* Whiteaves.

The Shamattawa limestone includes the following cephalopods:

Actinoceras parksi
Antiplectoceras shamattawaense
Apsidoceras boreale
Armenoceras magnum
Armenoceras cf. richardsoni
Billingsites boreale
Cycloceras acutoliratum
Cycloceras sp.
Cyrtogomphoceras shamattawaense
Diestoceras tyrrelli
Endoceras fulgur
Ephippiorthoceras dowlingi
Geisonoceras sp.
Huronia septata
Kochoceras shamattawaense
Oocerina shamattawaense
Parksoceras lepidodendroides
Rizoceras coronatum
Shamattawaceras ascoceroides
Spyroceras geronticum
Tripteroceras shamattawaense
Tyrrelloceras striatum
Westenoceras contractum

In this list it will be noted that such characteristic genera, as it holds in common with the Ordovician of southern Manitoba, occur in the Winnipeg limestone of that area. These genera include *Apsidoceras, Armenoceras, Billingsites, Cyrtogomphoceras, Diestoceras, Huronia,* and *Westenoceras.*

Some of these genera are well represented in the Richmond of Anticosti.[6] *Apsidoceras, Billingsites, Diestoceras,* and *Ephippiorthoceras* occur in all three members of the Richmond,—the English Head, the Vaurial, and the Ellis Bay, naming these members in ascending order. Moreover, all of these genera are represented by several species in the Anticosti Richmond. *Armenoceras* occurs both in the English Head and Vaurial members, and ranges thence to the Chicotte, at the top of the Silurian section on Anticosti.

Billingsites and *Diestoceras* range as far southward as the typical Richmond of Ohio and Indiana, where they occur in the Whitewater member of the Richmond, associated with *Tripteroceras,* and *Lambeoceras.*

Of unusual interest is the discovery by Dr. R. C. Hussey,[7] of the University of Michigan, of a fauna at the top of the Rich-

[6] Twenhofel, The Anticosti Island Faunas; 1914.
[7] Hussey, Dr. R. C. The Richmond Formation of Michigan, Contributions Mus. Geol. Univ. Michigan, 2, 1926, pp. 145, 176.

mond section as exposed on the peninsula east of Escanaba, in northern Michigan, which includes *Calapoecia cribriformis*, *Columnaria* (*Palaeophyllum*) *stokesi*, *Halysites gracilis*, and an abundantly nodulated species of *Beatricea*, apparently identical with, or at least closely similar to *Beatricea nodulifera* Foerste, from near the base of the Liberty member of the Richmond at Lebanon, Kentucky. This zone lies above the strata studied by Foerste[8] along the western margin of the same peninsula. The corals in the preceding list are those well known in both the Shamattawa and Nelson limestones of the area southwest of Hudson Bay, and also in the Ordovician strata of southern Manitoba, suggesting that the latter formations possibly belong above those formations in the northern part of the Mississippi Basin which it is customary to correlate with the Fernvale of Tennessee, Missouri, and southern Illinois.

CORRELATION OF PORT NELSON LIMESTONE

The Port Nelson limestone immediately overlies the Shamattawa limestone. Its most characteristic fossil is *Virginia decussata* (Whiteaves),[9] originally described from the vicinity of Grand Rapids, on the lower part of the Saskatchewan river, a stream entering Lake Winnipeg at its northwestern margin. This horizon is correlated by Savage and VanTuyl with the basal part of the Stonewall limestone in southern Manitoba, and with the upper part of the Mayville limestone of Wisconsin and the northern peninsula of Michigan. The fauna included at this horizon in the Hudson Bay area is very small and does not include any species of cephalopods.

CORRELATION OF SEVERN LIMESTONE

With few exceptions, the species which so far have been identified from the Severn limestone also occur in the overlying Ekwan limestone, and some are known even from the still higher horizon known as the Attawapiskat limestone. Hence, its affinities

[8] Foerste, The Richmond Faunas of Little Bay de Noquette; 1918.

[9] Kindle, Notes on the Geology and Palaeontology of the Lower Saskatchwan River Valley; 1915.

appear to be with these overlying limestones rather than with some underlying formation.

Only one cephalopod is known at present from the Severn limestone, namely *Phragmoceras severnense.* The living chamber of this species has a slightly convex ventral vertical outline, except at its top, where the hyponomic sinus of the aperture projects abruptly forward in the form of a short spout. Species of *Phragmoceras* having this type of structure occur in the Attawapiskat limestone, and are common in the Racine, Guelph, and Cedarville dolomites. They occur also in the Waukesha dolomite, immediately beneath the Racine, but are not known at present at still lower horizons, though other forms referable to *Phragmoceras,* but with a different ventral outline, are known as low as the Chicotte member of the Silurian of Anticosti, which Ulrich regards as of Clinton age.

In the Grand Rapids region of Manitoba[10] the strata above the *Virgiana decussata* horizon contain *Pterinea occidentalis, Isochilina grandis latimarginata,* and *Leperditia hisingeri fabulina.* The Severn limestone contains *Camarotoechia* (?) *winiskiensis* in addition to the three species just named; and the Wabi formation[11] of the Lake Timiskaming area contains *Camarotoechia* (?) *winiskiensis, Rhynchospira lowi, Pterinea occidentalis,* and *Leperditia hisingeri fabulina.* Therefore all three of the horizons named are regarded as approximately equivalent.

CORRELATION OF EKWAN LIMESTONE

The Ekwan limestone contains relatively few cephalopods, and most of these are found in the lower third of the limestone as exposed on Ekwan river. At this lower horizon occur *Spyroceras boreale, Kionoceras septentrionale, Stokesoceras ekwanense, Discosorus parksi,* and *Tuyloceras percurvatum.* A single species, *Stokesoceras cylindratum,* was found in the upper part of the middle third of this Ekwan limestone.

On the Severn river, only 2 cephalopods were found in the

[10] Kindle, Notes on the Geology and Palaeontology of the Lower Saskatchewan River Valley; 1915; p. 9.

[11] Hume, The Palaeozoic Outlier of Lake Timiskaming; 1925; p. 32.

Ekwan limestone; namely, *Stokesoceras ekwanense*, and a *Kionoceras* resembling *Kionoceras orus* in having vertical striae in addition to the vertical ribbing. The first of these two cephalopods is from the middle third of the Ekwan limestone, and the second is from its upper third.

In this limited cephalopod fauna, *Stokesoceras ekwanense* appears related to *Stokesoceras engadinense* Foerste, which occurs chiefly in the Manistique formation in northern Michigan,[12] though known also from the upper part of the underlying Burnt Bluff formation. *Stokesoceras cylindratum* is related to *Stokesoceras romingeri* Foerste, whose distribution appears to be chiefly in the Burnt Bluff, with less frequent occurrences in the Manistique; it appears related also to *Stokesoceras gracile* (Foord) which occurs in the Manistique.

In a general way, the Burnt Bluff and Manistique faunas of northern Michigan show considerable resemblance, especially in their cephalopods, with those Silurian strata in the Lake Timiskaming area[13] which are correlated by Dr. George S. Hume with the Lockport.

CORRELATION OF ATTAWAPISKAT LIMESTONE

The cephalopod fauna of the Attawapiskat limestone is rich in the variety of genera included. In fact, the considerable variety of forms discovered so far gives promise of rich future discoveries, when investigation is continued. The following is a list of those species known at present:

Armenoceras hearsti	P
Armenoceras severnense	S
Cameroceras vantuyli	S
Chicagooceras longidomum	E
Cycloceras sinuoliratum	S
Ekwanoceras breviconicum	E
Endoceras hudsonicum	P
Ephippiorthoceras ekwanense	W
Huroniella inflecta	P
Huroniella subinflecta	S

[12] Foerste, Silurian Cephalopods of Northern Michigan; 1924; p. 76.

[13] Hume, The Palaeozoic Outlier of Lake Timiskaming; 1925; p. 38.

Kionoceras cancellatum	W
Octameroceras walkeri	P
Oocerina severnense	P
Pentameroceras rarum	P
Phragmoceras lineolatum	E
Phragmoceras parksi	S
Phragmoceras vantuyli	E
Phragmoceras whiteavesi	W
Phragmoceras whitneyi	P
Protokionoceras submedullare	S
Protophragmoceras boreale	E
Westenoceras (?) septentrionale	E

In the preceding list, the letter S designates those species which were found by Savage and Van Tuyl in the Attawapiskat limestone on the Severn River; the letter E designates those found by Savage and Van Tuyl in the Attawapiskat limestone of the Ekwan river; the letter P designates those described by Parks from the Limestone Rapids of the Severn river, where there is a possibility of admixture of Ekwan and Attawapiskat species, with the likelihood of these species being of Attawapiskat age; and the letter W designates those described by Whiteaves from the Ekwan river, and which probably are of Attawapiskat age. The species here listed as *Phragmoceras whiteavesi* was described originally by Whiteaves under *Phragmoceras lineolatum*, but here is separated from what is regarded as typical *Phragmoceras lineolatum.*

The most striking feature about this Attawapiskat cephalopod fauna is the relatively large number of forms with strongly contracted apertures belonging to the families *Phragmoceratidae* and *Trimeroceratidae.* This fauna includes 7 species of *Phragmoceras* (of which 5 are preserved well enough to receive specific names), one species of *Pentameroceras,* and 1 of *Octameroceras.* In addition there are 2 species with strongly contracted apertures which are not preserved well enough even for exact generic reference, but which are described here under the designations *Gomphoceras* and *Pentameroceras.* This group of species is of interest, since, in the present state of our knowledge of Silurian cephalopods, it presents an assemblage similar to that of the Racine of Wisconsin and northern Illinois, though not a single

species is common to the two areas. Moreover, the presence in the Attawapiskat limestone of such species as *Chicagooceras longidomum, Cycloceras sinuoliratum,* and *Ekwanoceras breviconicum* suggests approximate contemporaneity with the Racine fauna.

That the Attawapiskat fauna represents an invasion from the north, rather than from the Racine region, is suggested by the presence of 4 species among the Actinoceratidae; namely, *Armenoceras hearsti, Armenoceras severnense, Huroniella inflecta,* and *Huroniella subinflecta.* Actinoceratidae are rare in typical Racine faunas, but are common in the Burnt Bluff and Manistique in the northern peninsula of Michigan, and are common in the Silurian of Arctic North America, and in the archipelago north of this continent. Probably the Attawapiskat fauna is of later age than the Manistique since the latter is not known to contain Phragmoceratidae nor Trimeroceratidae.

Phragmoceras vantuyli is of special interest since it is peculiar in having an erect form, cuneate in outline when viewed from the side, and is closely related to *Phragmoceras anticostiense,* from the lower part of the Chicotte formation on Anticosti Island. This Chicotte formation is referred by Ulrich to the Clinton division of the Silurian.

Cameroceras vantuyli is a most remarkable instance of a type of structure surviving into typical Silurian times which originated in Ozarkin times and was long believed to have become extinct with the close of the Richmond. Nevertheless, its endocone is clearly defined and apparently typical in structure.

Endoceras hudsonicum, in its present state of preservation, is a remarkable fossil of unknown affinities. While originally identified as an *Endoceras,* it might be an *Actinoceras* with very long septal necks, the septal necks formerly having been connected by short connecting rings which are not preserved in the single specimen at hand. Even in that case *Endoceras hudsonicum* would remain a most unusual fossil in a Silurian assemblage, since in that case its nearest relative would be *Actinoceras anticostiense* (Billings), from the English Head member of the Richmond of Anticosti, no other Silurian form similar in character being known.

SOUTHAMPTON ISLAND

Among the cephalopoda collected by A. P. Low along the southern half of the western coast of Southampton Island, north of Hudson Bay, are *Armenoceras lowi, Armenoceras inclinatum, Armenoceras southamptonense, Armenoceras sp., Stokesoceras cf. perobliquum, Discosorus troedssoni,* and *Lowoceras southamptonense.* Possibly this is a northern extension of the Burnt Bluff and Manistique faunas of northern Michigan, and of the Silurian fauna in the Lake Timiskaming area. *Discosorus* occurs also in the northern part of Prince Regent Inlet, between the northern part of North Somerset and the northwestern margin of Baffin Island.

Judging from the fossils listed by Lambe and Ami in "The Cruise of the Neptune," by A. P. Low, in 1906, the Ordovician and Silurian sections on Southampton Island probably are similar to those southwest of Hudson Bay. *Streptelasma robustum* suggests the presence of the Winnipeg limestone, equivalent to the Nelson. *Dinorthis cf. subquadrata* and *Leptaena cf. nitens* suggest the Stony Mountain limestone, equivalent to the Shamattawa. A small and immature form of what appears to be *Virgiana decussata* suggests the Port Nelson limestone. *Stropheodonta acanthoptera, Camarotoechia ekwanensis,* and *Rhynchospira sp.* suggest either Severn or Ekwan limestone, or both. And *Pycnostylus elegans* suggests the Attawapiskat limestone. *Glassia variabilis* ranges through the Severn, Ekwan, and Attawapiskat limestone, southwest of Hudson Bay.

GREAT SLAVE LAKE

Silurian rock is exposed 2 miles southwest of Gypsum Point, at the southern end of the western shore of the North Arm of Great Slave Lake.[14] Here *Pycnostylus elegans* and *Pycnostylus guelphensis* occur in association with 3 species of cephalopods which are regarded as of upper Niagaran age. These species are characteristic of the upper part of the Lockport and of the overlying Guelph. They occur in the Attawapiskat limestone of the

[14] Hume, Ordovician and Silurian Fossils from Great Slave Lake; 1926; p. 61.

southwestern part of the Hudson Bay area, in the Niagaran of Southampton island, in the Lockport of the Lake Timiskaming area, and in the Lockport of southern Ontario. They occur also in the Guelph of southern Ontario, and in the equivalent strata of Wisconsin, and Ohio.

The accompanying cephalopods are described here as *Byronoceras* (?) *humei*, *Crateroceras* (?) *humei*, and *Phragmoceras* (?) *cameroni*. Though their relationship generically is somewhat in doubt, all present an appearance sufficiently similar to species known from the Racine of Wisconsin and northern Illinois to suggest a Niagaran age for the Silurian strata found on Great Slave Lake. This merely corroborates the evidence presented by the presence of *Pycnostylus*.

Red Rock Point is 30 miles north of Gypsum Point. Ten miles northwest of Red Rock Point, in the bay between Spruce and High Points, there is an exposure containing a *Receptaculites* similar to *Receptaculites oweni*, and farther north rocks of about the same age contain *Halysites gracilis* and *Paleofavosites asper*. The *Receptaculites* suggests Nelson limestone age. The *Halysites* and *Paleofavosites* suggest Shamattawa age. Associated with the *Receptaculites* were 3 cephalopods, here described as *Endoceras* (?) *sp.*, *Orthoceras* (?) *slavense* and *Plectoceras* (?) sp. Two of these species, here referred to *Orthoceras* and *Plectoceras*, are so different from typical specimens of the genera to which they are assigned, that their generic relationship can be regarded as unknown. The *Endoceras*, however, appears to be a typical *Endoceras*, and suggests Ordovician age.

ARCTIC ORIGIN OF HUDSON BAY FAUNAS

From the preceding lines it will be observed that a study of the cephalopods from the Ordovician and Silurian faunas of the Hudson Bay area confirms the conclusions already drawn from a study of the other fossils found associated with these cephalopods in that area; namely, that these faunas are of Arctic origin. This origin is indicated on the palaeogeographic maps published by Savage and Van Tuyl[15] in their report on 1919 on this area.

[15] Savage and VanTuyl, Geology and Stratigraphy of the area of Paleozoic rocks in the vicinity of Hudson and James bays; 1919; pp. 354, 369, 371.

Recently this Arctic origin of the Ordovician part of the Hudson Bay faunas was confirmed in a most unexpected and thorough manner by the studies of Troedsson[16] on the Richmond cephalopods from Cape Calhoun, on the northwestern coast of Greenland. These show that the cephalopods from the Richmond at Cape Calhoun are remarkably similar to those from the Winnipeg limestone of southern Manitoba and from the corresponding Nelson limestone of the Hudson Bay area. Their relationship to the cephalopods of the Shamattawa limestone of the Hudson Bay area is not so striking.

The Port Nelson and Severn limestones appear to be of more local distribution, and neither is known from farther north than the southwestern part of the Hudson Bay area. Both occur along the lower part of the Saskatchewan river, and the equivalent of the Severn limestone is known from the Lake Timiskaming area.

The Ekwan limestone, however, possibly may be another case of a formation whose fauna has a long north and south extension, the northern end reaching far into the Arctic. The evidence, however, is very meager. It all depends on the degree to which an association of *Discosorus*, *Stokesoceras*, and *Actinoceras* proves diagnostic of approximately the same fauna. This association is well known on the northern peninsula of Michigan,[17] including Drummond Island; and in the Lake Timiskaming area[18] south of the southern end of James Bay. Possibly the Ekwan limestone along the southwestern part of the Hudson Bay area is approximately of the same age. The Silurian along the southern half of the west shore of Southampton Island, north of Hudson Bay, contains *Discosorus*, *Stokesoceras*, and a considerable variety of *Actinoceras*. *Discosorus* occurs also along the northern half of Prince Regent Inlet,[19] between the northern half of North Somerset and the northwestern margin of Baffin Land. Farther

[16] Troedsson, On the Middle and Upper Ordovician Faunas of Northern Greenland; pt. 1, Cephalopods; 1926; p. 113-4

[17] Foerste, Silurian Cephalopods of Northern Michigan; 1924.

[18] Foerste, Cephalopods of Lake Timiskaming Area and related species; 1925.

[19] Lee, Note on Artic Palaeozoic Fossils from the "Hecla" and "Fury" collections; 1912.

north, the *Discosorus* element of this fauna is unknown, but a species closely resembling *Armenoceras sphaeroidale* (Stokes) was collected by the expedition of the "Alert" and "Discovery" during the year 1875–76 somewhere between northern Greenland and Ellesmereland, possibly in Dobbin Bay. This species was described originally from Drummond Island, probably from the Manistique formation.

The Attawapiskat limestone is similar to the Racine limestone in containing a considerable variety of species of *Phragmoceras*, and at least one species of *Pentameroceras* and one of *Octamero-ceras*. That the relationship with the Racine is not close is shown by the fact that not one diagnostic cephalopod species is common to the Attawapiskat limestone and the Racine dolomite. Recently Schuchert and Dart[20] have made the very significant statement that the various faunas of the Chaleur series, which lie in the same trough as that on Anticosti, "show that the Niagaran (faunas) of interior America probably came largely from the St. Lawrence geosyncline and northwestern Europe. When the Silurian faunas of Anticosti and Quebec are fully described, it probably will be seen that many of the species now best known from the Chicago-Racine area are also common to the St. Lawrence trough. Earlier we were inclined to agree with Weller that most of the interior faunas came from the Arctic realm, and whereas some of them did, most of them were in connection with the St. Lawrence sea and so on to Europe." Savage and Van Tuyl showed that fauna of the Niagaran rocks of Illinois and New York did not enter the interior of the continent by the Hudson Bay route.

At present almost nothing is known of the Silurian in far northern areas. *Armenoceras backi* (Stokes) is cited by Foord[21] from Cape Louis Napoleon, on the western shore of the Kane Basin, and from Bessels Bay, on the eastern shore of Kennedy Channel. *Kionoceras darwini* (Billings) is cited from the Niagaran of Offley Island near the northern end of Kennedy Channel; and

[20] Schuchert and Dart, Stratigraphy of the Port Daniel-Gascons area of southeastern Quebec; 1926; p. 44.

[21] Foord, Catalogue of the Fossil Cephalopoda, pt. 1; 1888; pp. 183, 78, 40.

a species described as *Orthoceras arcticum* is cited by Foord from the same island and horizon. This so-called *Orthoceras* has considerable resemblance to *Monocyrtoceras lentidilatatum* Foerste[22] from the Racine of Wisconsin, and is the only species from the Arctic which at the present stage of our investigations suggests any relationship with the Racine.

On the other hand, it is becoming more and more obvious that the Arctic is occupied by various faunal provinces which are more or less restricted to the Arctic. Migrants from these provinces at times found their way far southward along epicontinental channels and seas; but in general, the more southern faunas, for instance those of Anticosti, southern Ontario, and the northern United States, show little evidence of having crossed over the Arctic, and thus establishing connection with the Eurasiatic continent by a trans-Arctic path, during Ordovician and Silurian times. Later, during Devonian and Carboniferous times, such a route of migration may have been in use.

The recent studies by Alice E. Wilson[23] of the Richmond in the Rocky Mountain area of British Columbia, show numerous faunal differences between this western Richmond and that of the southern part of Manitoba or the southwestern part of the Hudson Bay area. The very peculiar Silurian faunas from Alaska upon which Edwin Kirk is working at present, show little in common either with the Silurian of the more central parts of Canada or with that of the more northern parts of Europe. Until a correspondence between Ordovician or Silurian Faunas on opposite sides of the Arctic can be demonstrated more fully than in the past, migration of any considerable faunas across the Arctic, as formerly supposed, had better be regarded as awaiting proof.

LIST OF SPECIES DESCRIBED

1. *Endoceras nelsonense*
2. Endoceras fulgur
3. Endoceras sp. (Great Slave Lake)

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[22] Foerste, Notes on American Paleozoic Cephalopods; 1924; p. 260.

[23] Wilson, An Upper Ordovician Fauna from the Rocky Mountains, British Columbia, 1926.

4. Endoceras hudsonicum
5. *Cameroceras vantuyli*
6. Billingsites boreale
7. *Shamattawaceras ascoceroides*
8. Orthoceras sp. (Severn River)
9. *Orthoceras* (?) *slavense*
10. Geisonoceras (?) sp. (Shamattawa River)
11. *Cycloceras acutoliratum*
12. Cycloceras (?) sp. (Shamattawa River)
13. *Cycloceras* (?) *sinuoliratum*
14. *Spyroceras geronticum*
15. *Spyroceras boreale*
16. Kionoceras cancellatum
17. Kionoceras sp. (Severn River)
18. *Kionoceras septentrionale*
19. *Protokionoceras submedullare*
20. *Ephippiorthoceras dowlingi*
21. Ephippiorthoceras ekwanense
22. Parksoceras lepidodendroides
23. *Tripteroceras shamattawaense*
24. *Chicagooceras welleri* (Chicago area)
25. *Chicagooceras* (?) *longidomum*
26. *Rizoceras* (?) *coronatum*
27. *Ekwanoceras breviconicum*
28. Cyrtorizoceras (?) sp. (Severn River)
29. Dunleithoceras cordatum
30. Westenoceras (?) sp. (Nelson River)
31. *Westenoceras* (?) *contractum*
32. *Westenoceras* (?) *septentrionale*
33. Plectoceras sp. (Great Slave Lake)
34. *Antiplectoceras shamattawaense*
35. *Tyrrelloceras* (?) *striatum*
36. *Apsidoceras boreale*
37. Actinoceras parksi
38. *Kochoceras shamattawaense*
39. Armenoceras cf. richardsoni
40. Armenoceras magnum
41. Armenoceras sp. (York factory)
42. *Armenoceras lowi*
43. *Armenoceras inclinatum*
44. *Armenoceras southamptonense*
45. Armenoceras sp. (Southampton)
46. Armenoceras hearsti
47. *Armenoceras severnense*
48. Huroniella inflecta
49. *Huroniella subinflecta*
50. Huronia septata
51. *Stokesoceras cylindratum*

52. Stokesoceras cf. perobliquum
53. *Stokesoceras ekwanense*
54. Stokesoceras (?) keewatinense
55. *Discosorus parksi*
56. *Discosorus troedssoni*
57. *Lowoceras southamptonense*
58. *Oocerina shamattawaense*
59. *Oocerina* (?) sp. (Shamattawa River)
60. *Oocerina severnense*
61. Oocerina sp. (Severn River)
62. *Tuyloceras percurvatum*
63. *Byronoceras longidomum* (Illinois)
64. *Byronoceras* (?) *humei*
65. *Crateroceras raymondi* (Wisconsin)
66. *Crateroceras* (?) *humei*
67. Diestoceras sp. (Nelson River)
68. Diestoceras tyrrelli
69. *Cyrtogomphoceras nutatum*
70. *Cyrtogomphoceras* (?) *shamattawaense*
71. *Protophragmoceras* (?) *boreale*
72. Protophragmoceras (?) sp. (Ekwan River)
73. Protophragmoceras (?) sp. (Ekwan River)
74. *Phragmoceras severnense*
75. Phragmoceras nelsonense
76. Phragmoceras sp. (Severn River)
77. *Phragmoceras parksi*
78. *Phragmoceras* (?) *cameroni*
79. Phragmoceras lineolatum
80. *Phragmoceras whiteavesi*
81. Phragmoceras whitneyi
82. Phragmoceras sp. (Ekwan river)
83. *Phragmoceras vantuyli*
84. Gomphoceras (?) sp. (Severn River)
85. Pentameroceras rarum
86. Pentameroceras (?) sp. (Severn River)
87. *Octameroceras walkeri*

A. Zaphrentis (?) sp. (Severn River)
B. Euomphalus cf. rotundus

In the preceding list the names of the new species are italicized.

NEW GENERA

Shamattawaceras; genotype, *Shamattawaceras ascoceroides*
Parksoceras; genotype, *Orthoceras* (*Thoracoceras*) *lepidodendroides*
Chicagooceras; genotype, *Chicagooceras welleri*

Ekwanoceras; genotype, *Ekwanoceras breviconicum*
Antiplectoceras; genotype, *Discoceras shamattawaense*
Lowoceras; genotype, *Lowoceras southamptonense*
Tuyloceras; genotype, *Tuyloceras percurvatum*
Byronoceras; genotype, *Byronoceras longidomum*
Crateroceras; genotype, *Crateroceras raymondi*

ENDOCERAS Hall

Genotype: first published species—*Endoceras subcentrale* Hall, Pal. New York, 1, 1847, p. 59, pl. 17, fig. 4; accepted genotype—*Endoceras proteiforme* Hall, idem, p. 208, pl. 48, fig. 4; pl. 49, figs. 1 a-e; also Foerste, Denison Univ. Bull., 20, 1924, p. 208, pls. 21, 22, 23, 25.

1. **Endoceras nelsonense** Sp. nov.

Plate I, fig. 1

Specimen 245 mm. long, consisting only of a part of the phragmacone; flattened by pressure, the maximum diameter enlarging from 58 mm. at the base to 65 mm. at the top of the specimen. The minimum diameter at the base of the specimen is 30 mm. The number of camerae varies between 7 and 8 in a length equal to the maximum diameter of the conch. The sutures of the septa are directly transverse to the vertical axis of the conch. At the base of the specimen the maximum diameter of the siphuncle is 22 mm., or 38 per cent of the diameter of the conch. The center of the siphuncle is about 38 per cent of the diameter of the conch from its ventral side, in the present condition of the specimen. While this estimate may not be strictly correct, it is sufficiently accurate to indicate that the siphuncle is at least moderately eccentric in location, but not sufficiently so to bring it near contact with the ventral wall of the conch.

Locality and Horizon—Nelson river; at horizon 3, in the Nelson river limestone. Specimen No. 1 HB in the Savage collection.

2. **Endoceras fulgur** (Billings)

Plate II, fig. 1

Orthoceras propinquum Billings (not Eichwald). Geol. Surv. Canada, Rep. Progress for 1853–56, published in 1857, p. 320.
Orthoceras fulgur Billings, Geol. Surv. Canada, Cat. Sil. Foss. Anticosti, 1866, p. 22.

Specimen 145 mm. long, of which 40 mm. belongs to the lower part of the living chamber. Along the lower part of the specimen its maximum diameter is 100 mm., and its minimum one is 54 mm., the specimen being flattened by pressure. No increase in diameter is perceptible within the short length preserved. The specimen is a cast of the interior of the conch, and where this cast is least weathered it presents no trace of annulation, though elsewhere the weathering away of the surface of the cast in the vicinity of the sutures of the septa has resulted in a weakly annulated appearance. These sutures are directly transverse to the vertical axis of the conch. The lowest 3 camerae occupy a total length of 21 mm.; the next 7, of 38 mm.; and the upper 7, of 36 mm. Apparently the conch had reached its gerontic stage of growth.

Locality and Horizon—Shamattawa river, at horizon 1, in the Shamattawa limestone, 7 miles farther up stream than the main exposure of this limestone. Here the limestone is brought above drainage by a fold in the strata. No. 2 HB in the Savage collection.

Remarks.—This specimen resembles *Endoceras fulgur*, from the English Head member of the Richmond formation on Anticosti Island, in its small rate of enlargement, its relatively numerous camerae, and in the directly transverse course of the sutures of its septa. Since the Shamattawa river specimen presents no trace of its siphuncle, its reference to *Endoceras* is tentative. The type of *Endoceras fulgur* also does not retain its siphuncle, but similar specimens from the same locality and horizon possess siphuncles about half the diameter of the conch, the center of the siphuncle being only 8 mm. ventrad of the center of the conch, where the diameter of the latter is 80 mm.

3. Endoceras sp. (Great Slave Lake)

Plate I. figs. 2 A, B

Endoceras sp., Foerste, Geol. Surv. Canada, Bull. 44, 1926, p. 66, pl. 14, figs. 1 A, B.

Conch 160 mm. long, enlarging at a rate of 10 mm. in a length of 100 mm., and attaining a diameter of 56 mm. near its larger

end. Ten camerae occur in a length equal to the diameter of the conch. The sutures of the septa are directly transverse along the upper part of the specimen, and their downward curvature along its lower part is regarded as due to distortion. Passing through the entire length of the specimen is a lighter colored body, interpreted as the siphuncle, though no distinct trace of the limiting walls of this siphuncle remain. The ratio of the diameter of this siphuncle to that of the conch is 0.42 at the base and top of the specimen, also at the middle where a cross-section is exposed by a transverse fracture. However, the distance of the siphuncle from the ventral wall of the conch appears to vary. At the base of the specimen the siphuncle is almost in contact with the ventral wall. At the top of the specimen, only the dorsal and lateral walls of the siphuncle are definitely outlined, but if the lateral curvature of these parts be continued also around its ventral outline, the latter would be about 5 mm. distant from the ventral wall of the conch. The surface of the shell, as far as known, was smooth.

Locality and Horizon.—Great Slave Lake, west side of North Arm, 10 miles northwest of Red Rock Point. Collected by Dr. George S. Hume.

Remarks.—This species is characterized by its relatively numerous camerae.

4. Endoceras (?) hudsonicum Parks

Plate II, fig. 4

Endoceras hudsonicum Parks, Bur. Mines of Ontario, 22nd Rep., 1913, p. 195; Trans. Royal Canadian Inst., 1915, p. 72, pl. 5, fig. 10.

Type.—Conch distorted by oblique pressure. In its present condition its longer diameter is 108 mm., the shorter one is 83 mm., the corresponding diameters of the siphuncle being 41 mm. and 31 mm., indicating a ratio of 0.38 between the diameter of the siphuncle and that of the conch. The center of the siphuncle is 10 mm. distant from the center of the conch, which is a small excentricity for a conch 108 mm. in diameter. The sutures of the septa apparently curve moderately downward on the ventral side of the conch. In a length of 60 mm. there are 9 camerae,

which is equivalent to 16 camerae in a length equal to the present maximum diameter of the conch. Owing to pressure, the septa and septal necks are displaced considerably. Nevertheless, it seems certain that the lower ends of these necks failed to reach the upper margin of the necks beneath. Where best preserved, the walls of these necks appear to have been vertical. The surface of the shell apparently was smooth.

Locality and Horizon.—Limestone rapids on the Severn river; either from the Ekwan or Attawapiskat limestone. No. 322S in the Royal Ontario Museum of Paleontology.

Remarks.—The termination of the lower margin of the septal necks a short distance above the neck next beneath is a feature unknown in *Endoceras*. However, something similar is known in the type of *Actinoceras anticostiense* (Billings), in which the septal necks are distinctly longer than the intermediate connecting rings along the lower part of the conch.

CAMEROCERAS Conrad

Genotype: *Cameroceras trentonense* Conrad, Pal. New York, 1, 1847, p. 221, pl. 56, figs. 4 a-c; also Foerste, Denison Univ. Bull. 20, 1924, p. 212, pl. 24, figs. 1-5.

5. **Cameroceras vantuyli** Sp. nov.

Plate II, fig. 2

A fragment of a siphuncle (3 HB) 45 mm. long, beneath which protrudes a short endocone about 22 mm. in length. The lateral diameter of the siphuncle enlarges from 17.5 mm. to 20.2 mm. in a length of 35 mm., its dorso-ventral diameter at the top of this length being 22 mm. The siphuncle appears built up by a succession of septal necks, slightly invaginating at their bases, whose upper margins become free from the siphuncle at intervals of 5 mm., where they remain as low, narrow, inconspicuous, raised transverse lines. Judging from the direction of the lines, the location of the siphuncle was central, or nearly central. The tip of the endocone is directed obliquely ventrad, terminating 4 mm. from the nearest wall of the siphuncle, which is assumed to be ventral.

Another specimen (4 HB), from the same locality and horizon, consists of 2 septal necks of a siphuncle, with parts of 2 camerae still attached. The diameter of the siphuncle is 23 mm. Its nearest part is at least 20 mm. distant from the nearest wall of the conch. The camerae appear to be 5.5 mm. in height. The upper margins of the septal necks are directly transverse to the vertical axis of the siphuncle. In the vicinity of the siphuncle, these necks curve downward for a distance of 1.5 mm. before coming in contact with the lower part of the overlying neck. Laterally the conch extended at least 30 mm. from the siphuncle.

Locality and Horizon.—Severn river; at horizon 10, in the Attawapiskat limestone. Nos. 3 HB and 4 HB in the Savage collection.

Remarks.—Whiteaves[24] cited 2 fragments of siphuncles referable either to *Endoceras* or *Nanno* from the portage road at the falls on the Ekwan river, in strata also of Attawapiskat age.

BILLINGSITES Hyatt

Genotype: *Ascoceras canadense* Billings, Geol. Surv. Canada, Rep. Progr. for 1853–56, published in 1857, p. 310.

Billingsites Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 278; also Foerste, Denison Univ. Bull., 20, 1924, p. 217.

6. Billingsites boreale (Parks)

Plate III, figs. 4 A, B, C, D, 2, 3 A, B

Ascoceras boreale Parks, Bur. Mines Ontario, 22nd Rep., 1913, p. 192; Trans. Royal Canadian Inst., 11, 1915, p. 32, pl. 2, figs. 8,9.

Type.—Specimen consisting of the gerontic ovoid enlargement of the upper end of the conch, its lower end having been cast off at a cicatrix 21 mm. wide. The suture of this cicatrix slopes downward from the dorsal toward the ventral side at an angle of 25 degrees with the horizontal. The lateral diameter of the specimen is 36 mm., and the dorso-ventral one is 25 mm. The ventral side is slightly flatter than the dorsal one. At 50 mm. above the base, the specimen is constricted to a width of 29 mm. and a dorso-ventral diameter estimated at 22 mm., but only

[24] Whiteaves, Geol. Surv. Canada, Pal. Foss., vol. 3, pt. 4, 1906, p. 263.

the basal part of the short neck-like extension of the living chamber just beneath the aperture remains. The dorsal side of the upper half of the specimen is crossed transversely by the sutures of 4 septa, which curve downward laterally, and then coalesce as they continue to curve downward and dorsally until those on opposite sides of the specimen approach within 11 mm. of each other, where they curve strongly ventrad, joining the oblique suture outlining the cicatrix at the base. A vertical dorso-ventral section exposes at the base of the specimen several septa surrounding a siphuncle 3 mm. in diameter at the septal necks, the uppermost neck being 0.6 mm. in length, and its lower margin curving strongly outward, as in cyrtochoanitic siphuncles.

Locality and Horizon.—Lower rapids on the Shamattawa river; in the Shamattawa limestone. No. 326S in the Royal Ontario Museum of Paleontology.

Savage specimens.—Two specimens were obtained at horizon 1 in the Shamattawa limestone, 2 miles below the rapids, one on each side of the river. The better preserved specimen, No. 5 HB, is more depressed dorso-ventrally, as in the type; its lateral diameter being 31 mm., while its dorso-ventral one is only 22 mm. The second specimen, No. 6 HB, has a more nearly circular cross-section; whether natural or due to lateral compression is unknown. Both are in the Savage collection.

SHAMATTAWACERAS Gen. nov.

Genotype: *Shamattawaceras ascoceroides* Foerste and Savage.

Gerontic part of conch with an aspect similar to that of *Billingsites*, but its ventral side is much more strongly flattened in a lateral direction, and its dorsal and ventral aspects are quadrangular, rather than ovoid as in the genus mentioned. The dorsal saddles of the sutures are far less elevated and do not have the strongly sigmoid curvature of typical *Billingsites* and *Ascoceras*.

7. **Shamattawaceras ascoceroides** Sp. nov.

Plate III, figs. 1 A, B, C

Specimen 42 mm. long, enlarging laterally from a diameter of 33 mm. at its base to 37 mm. at mid-height; the dorso-ventral diameter enlarges from 23 mm. at the upper margin of the oblique basal suture to 25 mm. at mid-height, shortening to 21 mm. at the top of the specimen, its aperture not being preserved. The ventral side is strongly flattened, the remainder of the specimen presenting a nearly semicircular cross-section, which rounds evenly but rapidly into the flattened ventral area. In a lengthwise direction, the radius of convex curvature of the ventral side is 65 mm. The dorsal outline apparently was slightly gibbous along the top of the phragmacone. The specimen consists of the lower part of the living chamber and of the three upper camerae. The sutures of the septa approximate each other ventrally, their total height here being only 4 mm.; they form shallow ventral lobes, scarcely 3 mm. deep. Laterally the sutures rise strongly at successively steeper angles, producing conspicuous dorsal saddles. The siphuncle is assumed to have been located close to the ventral wall of the conch, if not in contact with the latter, but no trace of it remains.

Locality and Horizon.—Shamattawa river; Horizon 1, in the Shamattawa limestone. No. 7 HB in the Savage collection.

ORTHOCERAS Breynius

Genotype: *Orthoceras regulare* Schlotheim (?); see Breynius, Dissert. Phys. de Polythalmiis, 1732, pp. 12, 19, 31; pl. 3, figs. 1–7; also Foerste, Denison Univ. Bull. 20, 1924, p. 218; Schlotheim, Die Petrefactenkunde, 1820, p. 54.

8. **Orthoceras** sp. (Severn River)

Orthoceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 73.

Among the 4 specimens studied by Parks under this name, 3 are 35 mm. in diameter, and enlarge at a small rate. The siphuncle is 6.5 mm. in diameter and 7 mm. distant from the ventral wall of the conch. Apparently its segments are cylindrical in form and the surface of the shell is smooth, so that these frag-

ments may belong to typical *Orthoceras*, although the septa are stated by Parks to be only 6 mm. apart.

Locality and Horizon.—Limestone rapids of the Severn river; either from the Ekwan or the Attawapiskat limestone. No. 334S-a in the Royal Ontario Museum of Paleontology.

The fourth specimen from the preceding group, numbered 334S-b, has about the same diameter, but exposes no septa within its interior. Its exterior, however, is marked by 4 constrictions within a length of 20 mm., apparently locating levels at which the lower margin of the septal necks of some holochoanitic siphuncle invaginated into the tops of the septal necks immediately beneath. Possibly this fourth specimen is related to *Cameroceras tuyli*, described in this bulletin from the Attawapiskat limestone on the Severn river.

9. **Orthoceras** (?) **slavense** Sp. nov.

Plate VII, figs. 4 A, B

Orthoceras sp., Foerste, Geol. Surv. Canada, Bull. 44, 1926, p. 70, pl. 14, figs. 5 A, B.

Conch straight, depressed dorso-ventrally, with the siphuncle near the ventral side of the conch. The entire specimen is only 11 mm. long, and consists of 7 camerae. The lateral diameter enlarges from 8 mm. at the base to 10 mm. at the top, the corresponding dorso-ventral diameters being 7 mm. and 9 mm. The sutures of the septa curve slightly downward along the dorsal and ventral sides of the conch, resulting in shallow dorsal and ventral lobes and very low lateral saddles. The concavity of the septa has a radius of curvature of 10 mm. The siphuncle is located one-sixth of the dorso-ventral diameter from the ventral wall of the conch. It is narrowly cylindrical, and slightly exceeds half a millimeter in diameter.

Locality and Horizon.—Great Slave Lake, west side of North Arm, 10 miles northwest of Red Rock Point. Collected by Dr. George S. Hume.

Remarks.—This Great Slave Lake specimen differs from typical *Ephippiorthoceras* in the location of the lobes of the sutures of its septa, these lobes being dorsal and ventral, instead of

lateral, as in the latter genus. In consequence, the distinctly eccentric siphuncle is located along a diameter connecting the lobes, instead of one connecting the saddles of the sutures. Finally, the siphuncle is cylindrical in form, instead of having approximately globular segments. Nothing is known at present of the character of its living chamber.

GEISONOCERAS Hyatt

Genotype: *Orthoceras rivale* Barrande, Syst. Sil. Centre Boheme, 2, 1867, pl. 209. figs. 1-7.

Geisonoceras Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 275; also Foerste, Denison Univ. Bull. 20, 1924, p. 221.

10. Geisonoceras (?) sp. (Shamattawa River)

Plate IV, fig. 4

Orthoceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 23 (second specimen only).

Specimen 45 mm. long, enlarging from a diameter of 21 mm. at its base to 24 mm. at a point 24 mm. farther up. According to Parks, the shorter diameter of the conch was 20 mm. where its longer diameter was 25 mm. The septum at the base of the specimen has a concavity of 3 mm. The sutures of the septa are directly transverse. The surface of the shell is marked by fine transverse striae, of which the stronger ones number about 11 in a length of 5 mm. Nothing is known of the siphuncle.

Locality and Horizon.—Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 333S-b in the Royal Ontario Museum of Paleontology.

Remarks.—The transverse striae in this specimen are too numerous for typical *Geisonoceras*. In the latter genus the striae are relatively distant from each other, the intermediate areas being "banded." These banded areas slope faintly outward in an upward direction, their upper margins, therefore, rising distinctly above the level of the base of the next succeeding band.

CYCLOCERAS M'Coy

M'Coy, Syn. Carb. Foss. Ireland, 1844, p. 6, fig. 6; also Foerste, Denison Univ. Bull. 20, 1924, p. 222; 21,1925, p. 27.

In practice M'Coy referred to *Cycloceras* all annulated orthoconic cephalopods, irrespective of their other surface ornamentation. His original definition of the genus is applicable only to a peculiar species in which the surface of the shell is ridged vertically, as wel as transversely annulated and striated, and in which the location of the siphuncle is distinctly ventral. However, in the text following this original description of the genus he refers to *Cycloceras* three annulated species from the Carboniferous of Ireland which belong to a group of species in which the siphuncle is subcentral or only moderately excentric. The first two species M'Coy regarded as smooth, aside from the annulations, but the third had transverse striae in addition to the annulations, but no vertical ones. It is evident that, after writing his description of the genus, M'Coy desired to enlarge very much his original conception of the genus, so as to include all annulated forms. This he expressed in connection with his description of the second species described by him under the name *Cycloceras*, namely *Cycloceras laevigatum* M'Coy, stating that "This species belongs to the very interesting but difficult division of the *Orthoceratites*, to which, from the prominent ring-like elevations on the surface, I have given the name of Cycloceras." In case the first species described under *Cycloceras* be regarded as the genotype, this first species is that originally described as *Orthoceras annularis* Fleming. However, if the standing of a genus is based on its original description, this doubtful honor belongs to *Orthoceras rugosum* Fleming, the only species known to M'Coy at the time of his original description of *Cycloceras*, which conformed both to his original description and had any resemblance to the small figure accompanying this original description. Moreover, this species is cited by M'Coy in his British Palaeozoic Fossils, 1855, p. 573, under the name *Orthoceras* (*Cycloceras*) *rugosum* M'Coy, citing the original publication by Fleming. On the following pages the term *Cycloceras*

is used provisionally for annulated orthoceroids having transverse striae, but no vertical ones, as far as known.

11. Cycloceras acutoliratum Sp. nov.

Plate V, fig. 10, plate VI, fig. 3

Specimen 80 mm. long, enlarging from a diameter of 7 mm. at its base to 17 mm. at a point 60 mm. farther up. At this upper point, the shorter diameter is 14.5 mm., the conch being moderately compressed, possibly owing to pressure. The number of annulations in a length equal to the diameter of the conch equals 5.5 along the lower and middle parts of the specimen, decreasing to 5 at its top. Along the upper part of the specimen they are 1 mm. in height and slightly more than 1 mm. in width where the width of the intervening grooves is slightly less than 3 mm. The thickness of the shell equals 1 mm. at the annulations and slightly less than this along the intervening grooves. The surface of the shell is distinctly striated transversely, 4 striations occurring in a length of 1.1 mm. within the transverse grooves, about one-third of the length of the specimen from its top; on the annulations these striations are somewhat more crowded. Possibly there are also some vertical striations, but, in the specimen at hand, the presence of vertical striae can not be definitely recognized.

Locality and Horizon.—Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 8 HB in the Savage collection.

Remarks.—This specimen is closely similar to *Spyroceras meridionale* Whiteaves, but the surface ornamentation of the latter is unknown, and it came from some Niagaran horizon in the Silurian.

Living chamber.—A living chamber (pl. VI, fig. 3), from the same locality and horizon, may belong to the same species. It is 25 mm. long. In the transverse groove between the annulations, at its base, it is 17 mm. wide and 14 mm. in diameter dorso-ventrally, narrowing to a width of 15.5 mm. at the broad constriction of the interior of the chamber 6 or 7 mm. from the aperture. The shell is thick, as in the preceding specimen, and the annulations are similar. Four of these annulations occur in a length

equal to the width of the conch. They slope downward from the dorsal toward the ventral side of the conch at an angle of 10 degrees with the horizontal, the suture of the septum at the base of the chamber sloping an equal degree in the opposite direction. No. 9 HB in the Savage collection. In the obliquity of the annulations along the living chamber this specimen resembles the type of *Spyroceras geronticum.*

12. **Cycloceras (?) sp. (Shamattawa River)**

Plate IV, fig. 5

Cycloceras (?) *sp. indet.*, Parks, Trans. Royal Canadian Inst., 11, 1915, p. 28, pl. 2, fig. 7.

Specimen faintly curved lengthwise, crossed by annulations which slope downward from the concave toward the convex side of the conch at an angle of 10 degrees with the horizontal. Its dorso-ventral diameter increases from nearly 14 mm. at its base to 15 mm. at a point 25 mm. farther up, the total length of the specimen being 35 mm. The cross-section of the conch probably was circular. The sutures of the septa slope slightly more than the annulations, but in the same direction. Six annulations occur in a length equal to the diameter of the conch. The sutures are slightly more closely spaced than the annulations. No trace of the shell is preserved, so that the character of its surface markings remains unknown. Under these circumstances the reference of this specimen to *Cycloceras* is only tentative.

Locality and Horizon.—Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 332S in the Royal Ontario Museum of Paleontology.

13. **Cycloceras (?) sinuoliratum Sp. nov.**

Plate V, fig. 4

Fragment 35 mm. long, with a lateral diameter of 16 mm. and a dorso-ventral one of 15 mm. at mid-length. The rate of enlargement of the conch appears to be somewhere between 6 and 8 degrees. The number of annulations in a length equal to the diameter of the conch is 8 along the lower half of the specimen, increasing to 9.5 along part of its upper half. About 7 camerae

occur in a corresponding length. The annulations curve distinctly downward ventrally for a distance of 1.5 mm., and rise about the same distance dorsally, but along the lateral sides of the conch they are horizontal for a relatively short distance. The crests of the annulations are broadly rounded, and rise about 0.3 mm. above the intermediate grooves, which are of about the same width. The shell is about one-fifth of a millimeter in thickness, and its surface is crossed by clearly defined transverse striae, strictly parallel to the annulations; about 10 striae occurring in a length of 3 mm. No vertical striae can be detected, and no trace of the siphuncle is present.

Locality and Horizon.—Severn river; at horizon 10, in the Attawapiskat limestone. No. 10 HB in the Savage collection.

Remarks.—Specimens with a similar curvature in the annulations occur in the Racine of Wisconsin and Illinois, but in the latter these annulations tend to become faint along the median part of their dorsal and ventral sides.

SPYROCERAS Hyatt

Genotype: *Orthoceras crotalum* Hall, Pal. New York, 5, pt. 2, 1879, pls. 42, 82, 113.
Spyroceras Hyatt, Proc. Boston Soc., Nat. Hist., 22, 1884, p. 276; also Foerste, Denison Univ. Bull. 20, 1924, p. 225.

14. Spyroceras geronticum Sp. nov.

Plate VI, figs. 1 A, B; plate V, figs. 3, 2

Specimen 210 mm. in length, of which 74 mm. belong to the living chamber. In its present condition the conch is strongly depressed dorso-ventrally, and its upper half is curved slightly lengthwise; moreover, the sutures of the septa slant downward from the convexly curved toward the concavely curved side of the conch. In attempting to determine which side of the conch is ventral it is noted that the annulations ornamenting the surface of the conch slope downward slightly more than the sutures of the septa along the phragmacone, and that this slope increases considerably on approaching the top of the living chamber. From this it is inferred that the concavely curved side of the specimen is the ventral one, the curvature being due to distortion. The lateral diameter of the specimen enlarges from 28 mm. at

its base to 39 mm. at a point 93 mm. farther up, and thence remains constant until within 10 mm. of the top of the phragmacone. From this point it narrows to a width of 31 mm. at the top of the living chamber. The corresponding dorso-ventral diameters, in the present condition of the specimen, are 25, 30, 28, and 29 mm. The number of camerae in a length equal to the lateral diameter of the conch varies from 5.5 at the base of the specimen to 6.5 along the middle and upper parts of the phragmacone. The sutures of the septa occupy the grooves between the annulations. The latter are almost 2 mm. in height, and hence are very conspicuous. Their crests are rounded. Along the living chamber the annulations rapidly become broader and more distant on approaching the top of the chamber, a gerontic feature. The siphuncle is nearly central in location. At a point between 50 and 60 mm. above the base of the specimen, the surface of the shell is ornamented by narrow vertical ribs about half a millimeter in width, about 11 in a width of 10 mm. If intermediate lines formerly were present, these are not preserved.

Locality and Horizon.—Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 11 HB in the Savage collection.

Additional specimens from Shamattawa river.—Two additional specimens were found at horizon 2, in the Shamattawa limestone. Both are strongly compressed laterally, have similar annulations and surface ornamentations, but one of them is distinctly curved lengthwise and the other is straight. The curvature is regarded as due to distortion. In the curved specimen (12 HB) 6 primary vertical ribs occupy a width of 9.5 mm.; intermediate to these are secondary raised lines, much smaller in width; and intermediate to the primary and secondary sets are tertiary raised lines, distinctly finer than the secondary ones. This is a type of ornamentation not uncommon in the group typified by *Spyroceras bilineatum* (Hall). These two specimens may be distinct from typical *Spyroceras geronticum*, but in the present state of our knowledge of the surface ornamentation of the latter it appears impossible to separate them. Nos. 12 HB and 13 HB in the Savage collection.

15. **Spyroceras boreale** Sp. nov.

Plate V, fig. 1

Specimen consisting of 2 fragments with a combined length of 50 mm. The upper fragment enlarges from a diameter of 20 mm. to 25.5 mm. in a length of 21.5 mm. The cross-section is circular; 7.5 camerae occur in a length equal to the diameter of the conch at the top of the series counted; the sutures of the septa are directly transverse; the concavity of the septa is 4 mm. at the top of the specimen; the location of the siphuncle is almost central; at the top of the specimen the septal necks are 3 mm. in diameter; the lateral walls of the segments of the siphuncle are not defined clearly, but appear to be cylindrical. The surface of the shell is annulated, these annulations also leave their impress upon the cast of its interior; 7 annulations occur in a length equal to the diameter of the conch, increasing to 8.5 in the upper fragment. The surface of the shell is ornamented by vertical riblets, of which 12 occupy a width of 10 mm. at the top of the specimen. These riblets are nearly equal in prominence, though locally there is a slight tendency toward alternation in size, but no intermediate striae are present.

Location and Horizon.—Ekwan river; at horizon 2, in the Ekwan limestone. No. 14 HB in the Savage collection.

Remarks.—Compared with *Spyroceras meridionale* Whiteaves, the number of annulations is greater, and the transverse grooves between the annulations are approximately of about the same width as the latter.

KIONOCERAS Hyatt

Genotype: *Orthoceras doricum* Barrande, Syst. Sil. Centre Boheme, 2, pt. 3, 1874, pl. 269.
Kionoceras Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 275.

16. **Kionoceras cancellatum** (Hall)

Kionoceras cancellatum Whiteaves, Pal. Foss., Geol. Surv. Canada, vol. 3, pt. 4, 1906, p. 264.

Whiteaves described several specimens of *Kionoceras* as having the surface of the shell marked by longitudinal ridges, separated

by wider grooves or intervals, with minute, close-set, transverse, raised lines between them. Cross-section of conch circular, and siphuncle central or subcentral.

Locality and Horizon.—Ekwan river, at the portage road at the falls, and at the middle rapid; both in the Attawapiskat limestone.

Remarks.—It should be noted that Whiteaves does not refer to the presence of fine vertical striae between the primary vertical ribs, as in typical *Kionoceras cancellatum.*

17. **Kionoceras** sp. (Severn River)

Plate V, fig. 5

Specimen about 50 mm. long, flattened by pressure, consisting of a living chamber 33 mm. long, below which are the remains of 2 camerae too badly crushed for measurement. The original diameter of the shell apparently was 33 mm., broadly constricted along mid-height to 30 mm. by a shallow area of contraction, probably due to an annular deposition of calcareous material upon the walls of the interior of the conch. The surface of the shell is ornamented by 31 vertical ridges, each about three-fourths of a millimeter in width, and but slightly elevated above the level of the slightly concave intermediate grooves. In addition there are numerous vertical raised lines, varying in number from 5.5 to 8 in a width of 2 mm. The inner layers of the shell are crossed by microscopic, but sharply defined, transverse striae, numbering 6 or 7 in a length of 1 mm.

Locality and Horizon.—Severn river; at horizon 8, in the Ekwan limestone. No. 15 HB in the Savage collection.

Remarks.—In the character of the ornamentation of the surface of the shell, this specimen resembles *Kionoceras orus* (Hall), but the latter has taller camerae.

18. **Kionoceras septentrionale** Sp. nov.

Plate IV, fig. 2

Specimen 45 mm. long, enlarging in diameter from 10 mm. at its base to 16 mm. at a point 23 mm. farther up; cross-section circular. The number of camerae in a length equal to the

diameter of the conch at the top of the series counted is 6 along the lower and middle parts of the specimen, increasing to 7 at its top. The sutures of the septa are directly transverse. The concavity of the septa slightly exceeds the height of one camera. The location of the siphuncle is central. At the top of the specimen, where its diameter is estimated to have been 19 mm., the diameter of the septal necks is 1.9 mm., and their length is about one-sixth of a millimeter. Within the camerae the segments of the siphuncle enlarge to 3.25 mm. in diameter, their height being about 2.5 mm., and their general outline being approximately globular. The surface of the shell is ornamented by vertical riblets, numbering 13 or 14 in a width of 10 mm. at the top of the specimen, and estimated at about 80 within the circumference of the conch. These riblets are approximately equal in size, between 0.35 and 0.4 mm. in width, and separated by spaces of about the same width. No additional striae, either vertical or horizontal, can be detected.

Locality and Horizon.—Ekwan river; at horizon 2, in the Ekwan limestone. No. 16 HB in the Savage collection.

Remarks.—*Kionoceras septentrionale* is closely related to an undescribed species from the Ellis Bay division of the Richmond formation on Anticosti Island. The latter, however, has a smaller rate of expansion.

PROTOKIONOCERAS Grabau and Shimer

Genotype: *Orthoceras medullare* Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 353, pl. 20, figs. 1, 2.
Protokionoceras Grabau and Shimer, North Amer. Index Fossils, 2, 1910, p. 58.

19. **Protokionoceras submedullare** Sp. nov.

Plate IV, fig. 7

Specimen 38 mm. long, enlarging from a diameter of 13.2 mm. at its base to 16 mm. at a point 33 mm. farther up; cross-section circular. There are no traces of the septa. At the base of the specimen a part of the surface of the shell is preserved. This is ornamented by numerous vertical raised lines, of which 7 or 8 occur in a width of 5 mm. These are crossed by transverse lines,

of which 9 or 10 occur in a length of 5 mm. The latter are slightly less prominent than the vertical riblets. Both sets of raised lines are well defined, though less prominent, on the surface of one of the inner layers of the shell, exposed by exfoliation, but are absent on the cast of the interior of the conch. This cast is faintly constricted at 5 equidistant points within a length equal to the diameter of the conch, but it is not known whether the sutures of the septa occurred at the same intervals.

Locality and Horizon.—Severn river; at horizon 10, in the Attawapiskat limestone. No. 17 HB in the Savage collection.

Remarks.—In the type of *Protokionoceras medullare* (Hall) there are about 70 primary vertical ribs, alternating with an equal number of secondary riblets of almost equal prominence. Intermediate between these two sets is a tertiary series of raised lines, usually very inconspicuous, and not distinctly defined in all the intervals where they might be expected. These vertical markings are crossed by low transverse striae, 6 or 7 in a length of 10 mm., which are broader than the larger vertical striae, but far less prominent. In addition to these broader transverse striae there are numerous very fine striae, of which 9 or 10 occur in a length of 3 mm., readily visible only under a lens.

In *Protokionoceras submedullare* there are 65 vertical riblets within the circumference of the conch, subequal in size, without intermediate striae, crossed by relatively prominent transverse striae at slightly shorter intervals.

EPHIPPIORTHOCERAS Foerste

Genotype: *Orthoceras formosum* Billings, Geol. Surv. Canada; Rep. Progress for 1853–56, published in 1857, p. 317.

Ephippiorthoceras Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, 1924, p. 86; also Memoir 145, Geol. Surv. Canada, 1925, p. 71, text fig. 7, pl. 11, fig. 11.

20. Ephippiorthoceras dowlingi Sp. nov.

Plate IV, figs. 3A, B

Specimen about 80 mm. long, distorted by pressure. In its present condition the dorso-ventral diameter at its base is 31 mm., and the lateral one is 34 mm., but originally the dorso-

ventral diameter probably was a little greater than the lateral one, and the apical angle probably was about 8 degrees in this dorso-ventral direction. The camerae number about 7 in a length equal to the maximum diameter of the conch at the top of the series counted. The sutures of the septa curve downward laterally about 4 or 5 mm., forming relatively deep lobes and conspicuous dorsal and ventral saddles. The curvature of the septa is only slight laterally, but much more distinct dorso-ventrally. The center of the siphuncle is located 13 mm. from the ventral wall, where the dorso-ventral diameter of the conch is 31 mm. Its septal neck here is 2.5 mm. in diameter, its segment enlarging to 7 mm. at mid-height within the camera at the base of the specimen. The septal neck is half a millimeter in length, and its lower margin curves strongly outward. The camera here is 5 mm. in height.

Locality and Horizon.—Shamattawa river; at horizon 2, in the Shamattawa limestone. No. 18 HB in the Savage collection.

Remarks.—A second specimen, numbered 19 HB in the Savage collection, was found at horizon 1, in the Shamattawa limestone on the same river. It also is distorted, but with the dorso-ventral diameter longer than the lateral one.

21. **Ephippiorthoceras ekwanense** (Whiteaves)

Plate IV, figs. 1 A, B

Orthoceras Ekwanense Whiteaves, Geol. Surv. Canada, Pal. Foss., vol. 3, pt. 4, 1906, p. 265, pl. 33, figs. 1, 1a.

Conch enlarging dorso-ventrally at an apical angle of 20 degrees, and laterally at an angle of about 14 degrees. At the base of the specimen the dorso-ventral diameter is 38 mm.; at its upper end, where this diameter is 51 mm., the lateral one is 35 mm. The lower half of the specimen has been cut in a dorso-ventral vertical direction, exposing the septa. Here it is estimated that about 10 camerae occupied a length equal to the dorso-ventral diameter at the top of the series counted, the sutures of the septa curve distinctly downward laterally, forming broad lateral lobes and somewhat narrower dorsal and ventral saddles. The concavity of the septa equals the height of 3 camerae. At

the septal necks, the inner margins of the septa merely curve downward, but without curving outward at the lower margins of these necks, as in the cyrtochoanitic cephalopods. No trace of the connecting rings remains. The surface of the shell is smooth.

Locality and Horizon.—Portage road at falls of the Ekwan river; in the Attawapiskat limestone. No. 4414 in the collections of the Geological Survey of Canada.

PARKSOCERAS Gen. nov.

Genotype: *Orthoceras (Thoracoceras) lepidodendroides* Parks

Apparently an orthoconic shell, with its surface ornamented by more or less mammaeform elevations which tend to be arranged in diagonally intersecting rows. This is the most bizarre among the cephalopods studied by Prof. W. A. Parks from the Hudson Bay area, and we take great pleasure in naming this genus in his honor, in recognition of his very valuable contributions to our knowledge of the Ordovician and Silurian fossils from this area.

22. Parksoceras lepidodendroides (Parks)

Plate XVIII, figs. 3 A, B

Orthoceras (Thoracoceras) lepidodendroides Parks, Trans. Royal Canadian Inst., 11, 1915, p. 22, pl. 2, fig. 4.

Specimen 75 mm. long, including 8 camerae in a length of 53 mm.; strongly crushed dorso-ventrally, its width increasing from 54 mm. at its base to 58 mm. at a point 40 mm. farther up. In its present crushed condition, the dorso-ventral diameter is reduced to 34 mm. at the base of the specimen, though originally the cross-section may have been more nearly circular. Originally, also, the sutures of the septa may have been more nearly transverse, and the concavity of the septa may have been more moderate. The location of the siphuncle is unknown, unless a faint depression of the septum at the base of the specimen, slightly excentric in location and almost 5 mm. in diameter, represents the siphuncle. The specimen is of interest chiefly on

account of the unique character of its ornamentation. On one of its present flattened faces, the surface is ornamented by low and approximately circular elevations which are arranged along diagonally intersecting rows. These elevations are about 4 or 5 mm. in diameter and rise from half a millimeter to almost a whole millimeter above the general surface of the shell. Along these diagonal rows, 5 elevations occur in a distance varying from 26 to 32 mm. Along the lateral sides of the conch, which at present are strongly compressed, these elevations would be expected to be narrower laterally than tall, but their narrowness is in excess of the amount of compression of the conch, unless the conch originally was much more elongated in a direction at right angles to its present flattened faces than here supposed. Apparently 22 or 23 of these diagonal rows of elevations occurred within the circumference of the conch.

Locality and Horizon.—Lower rapids on the Shamattawa river; in the Shamattawa limestone. No. 321S in the Royal Ontario Museum of Paleontology.

TRIPTEROCERAS Hyatt

Genotype: *Orthoceras hastatum* Billings, Rep. Progr. for 1853–56, published in 1857, p. 333.

Tripteroceras Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 287; also Foerste, Denison Univ. Bull., 20, 1924, p. 231, pl. 31, figs. 3 A-D.

23. Tripteroceras shamattawaense Sp. nov.

Plate IX, fig. 10

Specimen 42 mm. long, apparently consisting only of the living chamber; enlarging laterally from a diameter of 14 mm. at its base to 21.5 mm. at its top, the corresponding dorso-ventral diameters being 9 mm. and 13 mm. The conch is distinctly flattened ventrally, and evenly convex dorsally, the cross-section being very similar to that of *Allumettoceras pauquettense* Foerste, but with the ventral side somewhat flatter. The septum at the base of the specimen slopes slightly downward from the dorsal toward the ventral side of the conch, curving only slightly in this direction. Laterally, however, this septum curves downward

with a radius of 9 mm., resulting in conspicuous lateral saddles, and relatively deep dorsal and ventral lobes. Unfortunately the specimen retains no trace of the siphuncle, which is assumed to be located near the flat side of the conch. No trace of surface ornamentation is preserved.

Locality and Horizon.—Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 20 HB in the Savage collection.

Remarks.—This Shamattawa specimen differs from typical *Tripteroceras hastatum* (Billings) chiefly in the even rounding of its dorsal side, the dorso-lateral faces of the conch not being flattened, nor separated by a broadly rounded median angularity, as in that species. Its relationship may be with *Allumettoceras*,[25] but, in the absence of any knowledge of the structure of its siphuncle, this must remain uncertain.

CHICAGOOCERAS Gen. nov.

Genotype: *Chicagooceras welleri* Foerste and Savage.

Conch erect, with its ventral outline distinctly more convex than its dorsal one, attaining its maximum diameter at the base of the living chamber; contracting thence as far as the aperture. The cross-section of the conch is circular along the lower part of the phragmacone, but becomes distinctly depressed dorso-ventrally farther up, the dorsal side being flatter than the ventral one. The sutures of the septa are straight, but slope slightly downward in a ventrad direction. The siphuncle is located slightly ventrad from the center of the conch, and its passage through the septa is small.

Chicagooceras differs from typical *Cyrtactinoceras* in not originating from a cyrtochoanitic ancestor. In *Cyrtactinoceras rebelle* (Barrande), the type of that genus, the type has subglobular segments with short cyrtochoanitic septal necks along the ventral side of the lower part of the phragmacone, and these segments become more cylindrical and occupy a position nearer the central

[25] Foerste, Denison Univ. Bull., Jour. Sci. Lab., vol. 20, 1924, p. 233, pl. 31, figs. 2 A-D (not figs. 3 A-D which illustrate *Tripteroceras hastatum* (Billings)); see also vol. 21, 1926, p. 311.

part of the conch at later stages of growth. No such changes in the form of the siphuncle are seen in *Chicagooceras*, and the small size of the passage of its siphuncle through the septum at the base of the genotype suggests a relatively narrow tubular series of segments, not cyrtochoanitic in structure.

24. **Chicagooceras welleri** Sp. nov.

Plate XXIV, fig. 4

Specimen 49 mm. long, consisting of an elongated living chamber 30 mm. in length ventrally and of 5 camerae of which the uppermost is distinctly shorter than the rest. The ventral convex vertical outline has a radius of curvature of 60 mm. along the phragmacone and the lower part of the living chamber, changing to 115 mm. along the upper part of this chamber. The dorsal vertical outline is only faintly convex. The conch is slightly depressed dorso-ventrally, especially above the base of the living chamber. At the base of the specimen the lateral diameter is 13.5 mm. and the dorso-ventral one is 13 mm.; the corresponding diameters at 5 mm. above the base of the living chamber are 20.5 mm. and 19 mm., and at the aperture they are 18.5 mm. and 16 mm. The sutures of the septa are straight, but slope distinctly downward in a ventrad direction. At the base of the specimen, where the dorso-ventral diameter is 13 mm., the center of the siphuncle is 5 mm. from the ventral wall of the conch. Its passage through the septum here is scarcely 1 mm. in diameter.

Locality and Horizon.—Bridgeport, a suburb of Chicago, Illinois; in the Racine member of the Niagaran. No. 21891 in Walker Museum at Chicago University.

25. **Chicagooceras (?) longidomum** Sp. nov.

Plate XVIII, figs. 2 A, B

Orthoceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 73, pl. 5, fig. 12.

Specimen consisting of an elongated living chamber which enlarges slightly at mid-length. Its lateral diameter increases from 13.5 mm. at its base to 16.5 mm. at mid-height, and dimin-

ishes to 15 mm. at the aperture. The corresponding measurements for the dorso-ventral diameter are 13 mm., 15.5 mm., and 14 mm. The convex lengthwise curvature of the ventral side is slightly greater than that of the dorsal side, having a radius of 100 mm., as contrasted with 150 mm. in the latter, the conch apparently being slightly curved lengthwise. The suture of the septum at the base of the chamber is straight and slopes downward from the dorsal toward the ventral side of the conch at an angle of 20 degrees with the horizontal. The concavity of this septum equals 3 mm. The center of the siphuncle is located 4.5 mm. from the ventral wall of the conch, and its septal neck is almost 1 mm. in diameter. The aperture of the chamber slopes from the ventral toward the dorsal side of the conch at an angle of 10 degrees with the horizontal. The surface of the shell is smooth.

Locality and Horizon.—Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 21 HB in the Savage collection.

Severn river specimen.—Living chamber 26 mm. long, to which 8 camerae, with a total length of 15 mm. are attached. The vertical axis of the conch is slightly curved lengthwise. The radius of convex lengthwise curvature of the ventral side is 110 mm. The dorsal outline is nearly straight until within 10 mm. of the aperture, where there is a slight convexity owing to the contraction of the living chamber at its top. The dorso-ventral diameter increases from 9.5 mm. at the base of the specimen to 13 mm. at the base of the living chamber, and to 15.5 mm. at a point 10 mm. from the aperture, and then decreases to 14.7 mm. at the aperture. The margin of the aperture is directly transverse. The sutures of the septa slant downward from the dorsal toward the ventral side of the conch. The maximum concavity of the septa is slightly ventrad of the center of the conch. The siphuncle is central in location, about one-third of a millimeter in diameter, and cylindrical in form. The surface of the shell is smooth.

Locality and Horizon.—Limestone rapids of the Severn river; either in the Ekwan or Attawapiskat limestone. No. 335S in the Royal Ontario Museum of Paleontology.

Remarks.—The siphuncle of the Severn river specimen ap-

pears to be smaller than that of the Ekwan river, and to be more nearly central in location; however, in the Ekwan river specimen the size of the siphuncle is not known definitely, but merely is inferred from the size of the upper part of the septal neck.

Compared with *Chicagooceras welleri* Foerste, the genotype of *Chicagooceras*, the Ekwan river specimen has a more elongated living chamber, with its maximum enlargement at mid-height of this chamber, rather than at its base. The downward slope of the septum at the base of this chamber also is greater in the latter specimen.

RIZOCERAS Hyatt

Genotype: *Orthoceras indocile* Barrande, Syst. Sil. Centre Boheme, 2, pt. 3, 1874, p. 57, pl. 185.

Rizoceras Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 276; also Foerste, Denison Univ. Bull. 21, 1926, p. 315, pl. 34, figs. 3 A-E.

26. **Rizoceras (?) coronatum** Sp. nov.

Plate V, fig. 7

Specimen 45 mm. long, slightly curved lengthwise, the convex ventral outline having a radius of 80 mm.; the dorsal side is assumed to be slightly concave, at least along the phragmacone. From the lateral curvature of the small part of the conch remaining it is estimated that the specimen originally enlarged from a diameter of 7 or 8 mm. at its base to about 27 mm. at its top. The specimen exposes 16 camerae within a length of 33 mm., above which extends an undifferentiated part which is assumed to belong to the living chamber. The sutures of the septa are nearly directly transverse to the curving vertical axis of the conch, but they rise sufficiently ventrally to produce a distinct, though low, angulation along the median part of this ventral side. It is estimated that along the upper part of the specimen 10 camerae occur in a length equal to the diameter of the conch at the top of the series counted. The siphuncle is close to the ventral wall of the conch and consists of narrow fusiform segments. The surface of the shell is ornamented by transverse striae which curve downward in a series of scallops. Along the median part

of the ventral side of the conch, the scallops form a vertical row, which along the lower part of the living chamber has a width of about 7 mm., the individual scallops curving downward about 1 mm. On each side of this median row there are two vertical rows, each about 5 mm. in width, in which the scallops curve downward only about half a millimeter. The remainder of the circumference of the conch is not preserved here. Probably about 15 series of scallops occupied the circumference of the conch.

Locality and Horizon.—Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 22 HB in the Savage collection.

Remarks.—Though very little of this conch remains, this little is sufficient to distinguish it from other American species so far described.

EKWANOCERAS Gen. nov.

Genotype: *Ekwanoceras breviconicum* Foerste and Savage.

Conch strongly curved lengthwise, rapidly enlarging as far as the aperture, circular or almost circular in cross-section. The hyponomic sinus is very shallow and is located on the convexly curved side of the conch. The siphuncle is central in location, and its enlargement within the camerae appears to be of a cylindroid nature.

From typical *Codoceras* it is distinguished by its much greater lengthwise curvature, and especially by the location of its hyponomic sinus, which is on the convexly curved side of the conch, instead of on its concave side as in that genus. Moreover, the segments of its siphuncle appear to be cylindroid even at the top of the phragmacone, and not broadly nummuloidal as in that genus.

27. **Ekwanoceras breviconicum** Sp. nov

Plate XXIII, figs. 2; 1 A, B

Specimen consisting of a living chamber 29 mm. in height, with a nearly circular cross-section, strongly curved lengthwise. The radius of curvature of its convex ventral side is about 40 mm.

The lateral diameter enlarges from 20 mm. at the base of the chamber to 43 mm. at its top. The dorsal outline is strongly concave, with a radius of 20 mm. near the base of the specimen, probably accentuated by dorso-ventral pressure here. The suture at the base is straight. The concavity of the septum equals 3 mm. The siphuncle is central in location. At the septal neck its diameter is 2.5 mm., and it enlarges within the camera beneath to a cylindroid form. Vertical converging plates, half a millimeter in length radially, extend inward from the walls of the siphuncle, as in actinosiphonate cephalopods. The surface of the shell is striated transversely; about 9 striae occur in a length of 5 mm. dorsally, and these curve downward about 1 mm. along the median part of the ventral side, indicating a broad, shallow hyponomic sinus, which tends to be angular along the middle.

Locality and Horizon.—Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 23 HB in the Savage collection.

Second specimen.—A second specimen from the same locality and horizon preserves only faint traces of the transverse striae ventrally, too poor to demonstrate the presence of a hyponomic sinus, but the general form of the living chamber is well preserved. The outline of the septum at its base is more clearly defined, but there is no trace of the siphuncle. No. 24 HB in the Savage collection.

CYRTORIZOCERAS Hyatt

Genotype: *Cyrtoceras minneapolis* Clarke, Geol. Minnesota, 3, pt. 2, 1897, p. 808, pl. 59, figs. 1-8.

Cyrtorizoceras Hyatt, in Zittel-Eastman's Text-book of Paleontology, 1900, p. 529; also Foerste, Denison Univ. Bull. 21, 1926, p. 316, pl. 35, figs. 3 A-C.

28. Cyrtorizoceras (?) sp. (Severn River)

Plate V, figs. 6 A, B

Ooceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 76 (second specimen only).

Living chamber with 4 camerae still attached; laterally compressed, and curved lengthwise, as indicated in the accompanying

figures. At the base of the living chamber, the dorso-ventral diameter is 10.5 mm., and the lateral one is 8 mm. The sutures of the septa curve downward about 1 mm. laterally, and reverse slightly in curvature on approaching the dorsal and ventral sides of the conch. No trace of the siphuncle is present, so that the generic relationship is determined from the general form of the conch.

Locality and Horizon.—Limestone Rapids of the Severn river; either in the Ekwan or Attawapiskat limestone. No. 336S-b in the Royal Ontario Museum of Paleontology.

DUNLEITHOCERAS Foerste

Genotype: *Cyrtoceras dunleithense* Miller and Gurley, Bull. Illinois State Mus. Nat. Hist., 11, 1896, p. 30, pl. 3, figs. 11, 12.
Dunleithoceras Foerste, Denison Univ. Bull. 20, 1924, p. 245.

29. **Dunleithoceras cordatum** (Parks)

Plate XV, figs. 1 A, B, C, D

Ooceras cordatum Parks, Trans. Royal Canadian Inst., 11, 1915, p. 86, pl. 3, fig. 3.

Specimen consisting of the basal part of the living chamber and of a considerable part of the phragmacone; laterally compressed; curved lengthwise; with a relatively prominent vertical rib along the median part of its convex ventral side. The radius of curvature of this side is 50 mm., that of the concave dorsal outline being 45 mm. The rate of enlargement dorso-ventrally is 10 degrees, laterally it is less. At the top of the phragmacone the dorso-ventral diameter is 25 mm. and the lateral one is 21 mm. The vertical rib has a total width of 6 mm. where the lateral diameter of the conch is 19 mm. The more flattened crest of this rib is slightly less than 4 mm. wide, and projects slightly more than 1 mm. beyond the general transverse curvature of the conch. The number of camerae in a length equal to the dorso-ventral diameter increases from 9 along the lower part of the specimen to 10 toward its top. The sutures of the septa curve downward laterally, rising more strongly ventrally than dorsally. Near mid-length of the specimen the passage of the siphuncle

through the septa is 2 mm. wide laterally and nearly 3 mm. in diameter dorso-ventrally, the increase in diameter dorso-ventrally being due to the upward slope of the septa ventrally. The ventral margin of the septal neck is 1 mm. distant from the ventral wall of the conch in direct measurement, but nearly 3 mm. distant when measured along the slope of the septum.

Location and Horizon.—From the drift of Nelson river; presumably from the Nelson limestone. No. 329S in the Royal Ontario Museum of Paleontology.

WESTENOCERAS Foerste

Genotype: *Cyrtoceras manitobense* Whiteaves, Trans. Royal Soc. Canada, 7, 1890, p. 80, pl. 13, figs. 3-5, pl. 15, fig. 4.
Westenoceras Foerste, Denison Univ. Bull., 20, 1924, p. 253.

30. Westenoceras (?) sp. (Nelson River)

Plate XVIII, figs. 1 A, B

Specimen 120 mm. long; in its present condition it is strongly depressed dorso-ventrally, but originally it was compressed laterally. In its present condition, the lateral diameter increases from 48.5 mm. at the base to 58 mm. at a point 4 camerae beneath the living chamber, above which it contracts to about 37 mm. at the aperture. This attenuation of the upper part of the conch is accompanied by the dorsad curvature of the upper half of the living chamber, its dorsal vertical outline being concave. The aperture appears to slope from the ventral toward the dorsal side of the conch. No trace of a hyponomic sinus is present. The ventral side of the phragmacone is weathered away, but a restoration of this side so as to conform to the curvature of the remainder of the conch in a lateral direction suggests a dorso-ventral diameter of 36 mm., in the present flattened condition of the specimen. In that case the center of the siphuncle would be about 10 mm. distant from the ventral wall of the conch; in other words, this siphuncle apparently was located about half way between the center of the conch and its ventral wall. Since the sutures of the septa slope downward toward the ventral side

of the conch at the base of the specimen, and rise at the base of the living chamber, it is probable that the ventral side of the conch was curved convexly in a lengthwise direction, while its dorsal outline may have been nearly straight. About 8 camerae occur in a length equal to the lateral diameter of the conch.

Locality and Horizon.—Nelson river; at horizon 4, in the Nelson limestone. No. 25 HB in the Savage collection.

Remarks.—This Nelson river specimen is of interest chiefly on account of its supposed relationship to *Westenoceras manitobense* (Whiteaves). However, it fails to show direct evidence of former lateral compression of the conch, or of distinct lateral lobes. On the other hand, it shows the peculiar attenuation of the upper part of that conch toward the aperture, and the dorsad curvature of the vertical axis of the latter toward its upper end.

31. Westenoceras (?) contractum Sp. nov.

Plate XVI, figs. 2 A, B

Specimen 54 mm. long, including 2 camerae and most of the living chamber, the aperture not being preserved; curved lengthwise, the radius of curvature of the convex ventral side being 50 mm., and that of the concave dorsal side being about 18 mm. The dorso-ventral diameter diminishes from 42 mm. at the base of the uppermost camera to 27 mm. at the highest point preserved, the lateral diameter diminishing from 34 mm. along the lower part of the living chamber to 21 mm. at the top. The aperture is not preserved. The sutures of the septa curve downward 5 mm. laterally, producing prominent dorsal and ventral saddles. The septum at the base of the specimen is not preserved. No trace of the siphuncle remains. The surface of the shell apparently was smooth.

Locality and Horizon.—Shamattawa river; at horizon 1, in the Shamattawa limestone, but 7 miles farther up the river than the main exposure of this horizon. No. 26 HB in the Savage collection.

Remarks.—The generic relationship of this species appears to be with the form described by Schuchert as *Oncoceras tumidum*,

rather than with *Westenoceras manitobense*. It resembles the latter chiefly in the attenuation of the upper part of its conch, and in the dorsad curvature of the upper part of its vertical axis.

32. **Westenoceras (?) septentrionale** Sp. nov.

Plate V, fig. 8

Specimen 60 mm. long; laterally compressed, with an elliptical cross-section; slightly curved lengthwise. The convex curvature of its ventral side has a radius of about 300 mm. The dorso-ventral diameter enlarges from 11 mm. at its base to 23 mm. at a point 48 mm. farther up, the corresponding lateral diameters being 10 mm. and 19 mm. Six camerae occur in a length equal to the dorso-ventral diameter of the conch at the top of the series counted. The sutures of the septa curve downward laterally producing lateral lobes and dorsal and ventral saddles. At the top of the specimen the depth of these lobes is 2 mm. The siphuncle varies in diameter from 2 mm. at the base of the specimen to 5.5 mm. at its top. The center of this siphuncle is 3.5 mm. from the ventral wall of the conch at the base of the specimen and 7 mm. at its top. The segments of the siphuncle are almost cylindrical in outline, enlarging but faintly within the camerae. The shell is almost half a millimeter thick, and its surface at present is slightly irregular, but originally probably was smooth.

Locality and Horizon.—Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 27 HB in the Savage collection.

Remarks.—The specimen here described may belong to an undescribed genus. Nothing is known of its living chamber. It is placed in *Westenoceras* merely to avoid the erection of a new genus on such insufficient material. It shares with that genus the location of the siphuncle at a distinct distance from the ventral wall of the conch. This siphuncle is relatively large, and its segments enlarge but slightly within the camerae. Moreover the sutures of its segments are curved downward laterally. However, it is much to be doubted whether its living chamber contracted toward the aperture, and the horizon of the specimen, in the Attawapiskat limestone, also makes its reference to *Westenoceras* extremely doubtful.

PLECTOCERAS Hyatt

Genotype: *Nautilus jason* Billings, Canadian Nat. Geol., 4, 1859, p. 464; also Whiteaves, Geol. Surv. Canada, Pal. Foss, 3, pt. 4, 1906, p. 301, pl. 36, figs. 1, 2.
Plectoceras Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 268.

33. Plectoceras (?) sp. (Great Slave Lake)

Plate VII, figs. 5 A, B, C

Trocholites sp., Foerste, Geol. Surv. Canada, Bull. 44, 1926, p. 71, pl. 14, figs. 6 A, B, C.

Specimen consisting of three-fourths of a volution of a strongly curved conch, enlarging from a dorso-ventral diameter of 3 mm. at its smaller end to 5 mm. at its larger one. At its smaller end the cross-section is circular. No evidence of contact with adjacent volutions is seen anywhere along the small part preserved, but the curvature of the fragment suggests that such contact must have taken place at a later stage of growth. The sutures of the septa curve moderately downward laterally. The concavity of the septa is distinctly greater dorso-ventrally than laterally, its radius of curvature being 3 mm. in the former direction, while 15 mm. laterally. This results in distinct dorsal and ventral saddles with intermediate lateral lobes. The siphuncle is located slightly less than one-fourth of the dorso-ventral diameter from the ventral wall of the conch. It is small and cylindrical. Where the diameter of the conch is 3 mm., that of the siphuncle equals scarcely one-fifth of a millimeter. It is estimated that about 8 camerae originally occupied a length of 7 mm. The surface of the shell is striated transversely, the striae being sharply defined, and numbering about 6 in a length of 2 mm. where the diameter of the conch is 5 mm. On the ventral side of the conch these striae curve downward, forming a shallow hyponomic sinus, which tends to be angular along the median line, the sides of this angle diverging at an angle of 152 degrees. On the dorsal side of the conch these striae are directly transverse.

Locality and Horizon.—Great Slave Lake, western side of North Arm, 10 miles northwest of Red Rock Point. Collected by Dr. George S. Hume.

Remarks.—The generic relationship of this specimen is unknown. It is referred provisionally to *Plectoceras* because no contact zone is present, and this is characteristic of early stages of growth in *Plectoceras*. There is no evidence, however, that the Great Slave Lake specimen developed distinct lateral ribs at later stages of growth as in *Plectoceras jason* (Billings). Moreover, its hyponomic sinus appears altogether too shallow for *Plectoceras*.

ANTIPLECTOCERAS Gen. nov.

Genotype: *Discoceras* (?) *shamattawaense* Parks, Trans. Royal Canadian Inst., 11, 1915, p. 31, pl. 1, fig. 1.

Conch slowly enlarging, volutions apparently in contact with each other, possibly with a shallow dorsal contact zone, but this is uncertain. Apparently compressed laterally, oval in cross-section, with the lateral sides converging in a ventrad direction. Surface transversely ribbed. The chief distinguishing feature of this genus is the downward curvature of these ribs laterally, with a distinct rise of these ribs both ventrally and dorsally. This suggests lateral sinuses along the aperture, separated ventrally by a more or less distinct elevation of the margin of this aperture.

34. Antiplectoceras shamattawaense (Parks)

Plate XXIV, fig. 2

Discoceras (?) *shamattawaense* Parks, Trans. Royal Canadian Inst., 11, 1915, p. 31, pl. 1, fig. 1.

Specimen retaining the impression of part of one of the lateral sides of a conch. Parts of at least three and one-eighth volutions are present. The umbilical opening appears to have been 10 mm. in diameter. Successive volutions appear to have been in contact with each other, possibly with a shallow dorsal contact zone, though this is not certain. The conch enlarges slowly. Its cross-section is oval, the dorsal side being broader, and the lateral sides converging in a ventrad direction. The conch is crossed transversely by ribs which curve slightly but distinctly downward laterally and rise moderately in a ventrad direction. These ribs are narrow and prominent dorsally, but broader and

lower ventrally, apparently becoming obsolete at the ventro-lateral parts of the conch. It is impossible to determine the lateral diameter of the conch from the lateral curvature of that part of the impression of the conch which remains, but it is assumed that the conch was compressed laterally, and that the lateral diameter was about 16 mm. where the dorso-ventral diameter of the conch is 20 mm. About 5 ribs occur in a length equal to the dorso-ventral diameter of the conch, when these ribs are counted along the middle of the lateral sides.

Locality and Horizon.—Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 325S in the Royal Ontario Museum of Paleontology.

TYRRELLOCERAS Foerste

Genotype: *Trochoceras insigne* Whiteaves, Geol. Surv. Canada, Pal. Foss., 3, 1906, p. 282, pl. 41.
Tyrrelloceras Foerste, Denison Univ. Bull. 21, 1925, p. 56.

35. Tyrrelloceras (?) striatum Sp. nov.

Plate IX, fig. 9; plate XIV, fig. 3

Specimen 42 mm. long, curving lengthwise with a radius of 40 mm. along its convex ventral side; compressed laterally. The dorso-ventral diameter increases from 15 mm. to 16.5 mm. in a length of 20 mm. The corresponding lateral diameters are 13.5 mm. and 14 mm. The median part of the ventral side appears slightly flattened, owing to the faintness of the transverse ribs here. The lateral sides are subparallel, and the median part of the dorsal side is more narrowly rounded than the corresponding part of the ventral side. The ribs are narrowest and most conspicuous dorsally; laterally they broaden and remain conspicuous as far as the ventro-lateral angles; but ventrad of these angles they curve downward and rapidly become weak, being almost obsolete along the median part of the ventral side; dorsad of these angles the ribs rise moderately. Along the dorsal side of the shell, its surface is minutely striated both longitudinally and transversely, about 6 or 7 striae in a length or width of 1 mm.; but ventrally 6 or 7 transverse striae occur in a length of 2 mm., and the longitudinal ones are slightly more numerous.

Along the median part of this ventral side about 5 of these longitudinal striae are more conspicuous than the rest and occupy a total width of 6 mm.; the transverse striae here curve downward fully as far as the transverse ribs. The septum at the base of the specimen rises dorsally, and its suture curves moderately downward laterally. The center of the siphuncle here is 5 mm. from the ventral wall of the conch, and its septal neck appears to be about 1.2 mm. in diameter, the dorso-ventral diameter of the conch being 15 mm.

Locality and Horizon.—Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 28 HB in the Savage collection.

Remarks.—This Shamattawa river specimen differs from *Discoceras* (?) *shamattawaense* Parks in being gyroceraconic, the transverse costae are relatively fewer, and slope distinctly downward in a ventrad direction. Compared with *Tyrrelloceras insigne* Whiteaves, the lateral sides of the conch are not strongly ribbed laterally in a longitudinal direction, and the sutures of the septa do not rise strongly ventrally. The latter is of Niagaran age.

APSIDOCERAS Hyatt

Genotype: *Gyroceras* (*Lituites*) *magnificum* Billings, Geol. Surv. Canada, Rep. Progress for 1853–56, published in 1857, p. 307.

Apsidoceras Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 289.

36. Apsidoceras boreale Sp. nov.

Plate XIV, figs. 1 A, B, C

Specimen 80 mm. long, curved lengthwise, its convex ventral side having a radius of 90 mm. Near mid-length its lateral diameter is 32.5 mm., and its dorso-ventral one is 28 mm. The ventral side is strongly flattened, the remainder of the cross-section forming more than half a circle. Five camerae occupy a length equal to the lateral diameter of the conch. The sutures of the septa form broad ventral lobes, equal in depth to the height of 1 camera, and also conspicuous dorso-lateral saddles. The siphuncle should be located ventrad of the center of the conch, but no trace remains.

Locality and Horizon.—Shamattawa river; at horizon 2, in the Shamattawa limestone. No. 29 HB in the Savage collection.

Remarks.—The Shamattawa specimen differs from typical *Apsidoceras magnificum* (Billings) chiefly in the smaller size of the conch, and its relatively greater dorso-ventral diameter. The number of its camerae is about the same.

ACTINOCERAS Bronn

Genotype: *Actinoceras bigsbyi* Bronn, Lethaea Geognostica, 1, 1837, p. 98, pl. 1, fig. 8; also Foerste, Contributions Mus. Geol. Univ. Michigan, 2, 1924, p. 31. pl. 1, figs. 1A, B, 2; pl. 12, figs. 7 A-C.

37. Actinoceras parksi Foerste

Actinoceras bigsbyi Parks, Trans. Royal Canadian Inst., 11, 1915, p. 23, pl. 6, fig. 7.
Actinoceras parksi Foerste, Bull. Denison Univ., 19, 1921, p. 297, pl. 35, fig. 3.

Compared with *Actinoceras bigsbyi* Bronn, the conch of *Actinoceras parksi* apparently enlarges at a smaller rate and the vertical height of the segments of the siphuncle does not increase as rapidly. The number of camerae in a length equal to the diameter of the conch is greater, and this is true also of the number of segments of the siphuncle compared with the diameter of the latter. The septal necks are relatively longer, and form a greater proportion of the vertical height of the camerae. The structure of this siphuncle, however, is similar to that of the genotype in the relatively great length of its septal necks, compared with the height of the camerae.

Locality and Horizon.—Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 308S in the Royal Ontario Museum of Paleontology.

KOCHOCERAS Troedsson

Genotype: *Kochoceras cuneiforme* Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, I, Cephalopods, 1926, published in Jubilaeumsekspeditionen Nord om Grønland, 1920–23, No. 1, p.6 8, pl. 37, figs. 2–4; pl. 38; pl. 39, pl. 40, figs. 1, 2; pl. 44, fig. 6.
Kochoceras, Troedsson, Ibid., 1926, p. 65.

"Breviconic or rarely longiconic orthoceracones with flattened ventral side and actineroceroid siphuncle. The latter is large, almost filling up the apical portion of the conch, and is tightly pressed against the ventral side of the conch until flattening and confluence of the annulations."

Named in honor of Dr. Lauge Koch, the leader of the expedition to Greenland. This expedition spent the autumn of 1921 at Cape Calhoun, where more than 1200 specimens of Ordovician fossils were collected. These include cephalopods, trilobites, brachiopods, gasteropods, corals, sponges, etc. The exposures extend along the southern coast of Washington land, on the northern shore of Kane Basin, in the northwestern part of Greenland. The section includes Cambrian, Ozarkian, and Ordovician beds. North of Cape Calhoun the Niagaran beds appear.

From this region Troedsson described *Kochoceras cuneiforme*, *K. cuneiforme robustum*, *K. ellipticum*, *K. ellipticum minutum*, *K. undulatum*, and *K. productum* from strata which he referred to the Richmond. Another species, *Kochoceras* (?) *vetustum*, doubtfully referred to this genus, was obtained from the Gonioceras Bay formation, which Troedsson doubtfully correlates with the Lowville.

Two additional specimens were figured by Foord in his Catalogue of Fossil Cephalopoda, pt. 1, 1888, p. 165. Of these, the one represented by his text-figure 22–1, came from Igloolik Island in the Fox Channel of Arctic America. The second, represented by figures 22–2 and 23, came from Great Slave Lake, in the northern part of Canada. Foord referred these species to *Actinoceras*.

To the species cited above are here added *Kochoceras lenticulare*, *K. mantelli*, *K. fieldeni*, and *K. shamattawaense*. Of these the first three are from various parts of Arctic America, and will be described in a later paper, while the species named last is from the Shamattawa limestone on the Shamattawa river, southwest of Hudson Bay, and is described in the present publication.

38. **Kochoceras shamattawaense** Sp. nov.

Plate VII, fig. 2

Actinoceras cf. bigsbyi Parks, Trans. Royal Canadian Inst., 11, 1915, *p. 25*, *pl. 6*, *fig. 6*.

Specimen 50 mm. long, consisting of the siphuncle to which the median part of the ventral wall of the conch is attached. The siphuncle is in contact with this wall only along the con-

necting rings, but is free at the septal necks, which extend about 1 mm. inward from the ventral wall. The dorso-ventral diameter of the siphuncle at its septal necks is 17 mm. On the dorsal side of the siphuncle, the connecting rings forming the annulations extend 4 mm. farther into the interior of the conch than do the septal necks; therefore, the total dorso-ventral diameter of the siphuncle is 22 mm. It is assumed that the cross-section of the siphuncle is depressed dorso-ventrally, although the latter is not fully exposed, and its lateral diameter is unknown. The annulations of the siphuncle are nearly directly transverse to the vertical axis of the siphuncle. The sutures of the septa curve downward along the ventral side of the conch. Along the dorsal side of the siphuncle, the septa rise dorso-ventrally at an angle of 25 degrees above the horizontal. Where the connecting rings forming the annulations are 7 or 8 mm. in height vertically, the height of the intermediate septal necks is about 2 mm. Only the lower half of the connecting rings is well preserved. There is no evidence of deposition of calcareous material within this siphuncle, which is very unusual in this type of conchs. The surface of the shell apparently was smooth.

Locality and Horizon.—Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 315S in the Royal Ontario Museum of Paleontology.

ARMENOCERAS Foerste

Genotype: *Actinoceras hearsti* Parks, Trans. Royal Canadian Inst., 11, 1915, p. 73, pl. 6, fig. 5; also this bull., p. 68, pl. viii, fig. 4; pl. xxiv; fig. 5.

Armenoceras Foerste, Contributions Mus. Geol. Univ. Michigan, 2, 1924, p. 32; also Memoir 145, Geol. Surv. Canada, 1924, p. 73.

39. Armenoceras cf. richardsoni (Stokes)

Plate XI, fig. 5

Actinoceras richardsoni Stokes, Trans. Geol. Soc. London, 2nd ser., vol. 5, 1840, p. 708, pl. 59, figs. 2, 3.

Specimen 84 mm. long, consisting of 12 segments of a siphuncle. Their diameter increases from 26 mm. at its base to 27 mm. at its top. The segments slope downward from the

ventral toward the dorsal side of the siphuncle at an angle of 5 degrees with the horizontal. The septa are adnate to the lower face of the segments of the siphuncle. These areas of adnation are best exposed along the ventral side of the specimen.

Locality and Horizon.—Shamattawa river; at horizon 2, in the Shamattawa limestone. No. 30 HB in the Savage collection.

Remarks.—In the type of *Armenoceras richardsoni* the siphuncle is about 30 mm. in diameter, but the number of segments and their degree of slope is closely similar to that of the specimen here described.

40. Armenoceras magnum (Parks)

Plate VIII, fig. 1

Actinoceras richardsoni magnum Parks, Trans. Royal Canadian Inst., 11, 1915, p. 25, pl. 2, fig. 1.

Specimen 150 mm. long, estimated by Parks to have been 120 mm. wide. In its present condition, it has been sectioned vertically through the center of the siphuncle, and the camerae are preserved only on one side of this siphuncle; the diameter of the siphuncle is 55 mm., and that part of the camerated shell which is preserved has an additional width of 33 mm., but no trace of the exterior of the shell remains to serve as a guide in locating the siphuncle. Apparently the section is dorso-ventral in direction since the lower face of the annulations of the siphuncle rises laterally on the left side of the specimen as oriented in the accompanying figure, but is more nearly horizontal on its right side. From this it is concluded that the location of the siphuncle was excentric. About 6.5 segments occupy a length equal to the diameter of the siphuncle. Where this diameter is 53 mm., the constriction at the septal necks is only 35 mm. in diameter. The septal necks are very short, and the distance between the successive nummuloidal segments is only half a millimeter. The septa are adnate to the lower face of the overlying segments, and their inner margins curve moderately downward on approaching the septal necks. Calcareous deposits line the inner walls of the siphuncle, the deposits being thickest along the lower part of the specimen. The central space, free

from calcareous deposits, is occupied at present by ordinary matrix, similar to that filling the camerae.

Locality and Horizon.—Mouth of Shamattawa river; in the Shamattawa limestone. No. 309S in the Royal Ontario Museum of Paleontology.

Remarks.—The siphuncle enlarges apparently at an apical angle of 5 degrees, which is distinctly larger than in *Armenoceras richardsoni*. Compared with the latter, the segments of the siphuncle are relatively more numerous.

41. **Armenoceras** sp. (York factory)

Plate IX, figs. 7 A, B

Actinoceras cf. clouei Parks, Trans. Royal Canadian Inst., 11, 1915, p. 86, pl. 2, fig. 6; pl. 6, fig. 1.

Specimen 52 mm. long, including 9 nummuloidal segments of a siphuncle, of which 4 occupy a length equal to the diameter. The latter enlarges from 21.5 at the base of the specimen to 22.5 mm. at its top. A small remnant of the ventral wall of the conch at the base of the specimen indicates that the nearest part of the siphuncle is scarcely 1 mm. distant from this wall. The segments slope downward toward the dorsal side of the siphuncle at an angle of 10 degrees with the horizontal. The septa in contact with the base of the segments rise, on the contrary, toward the ventral wall of the conch at an angle of 30 degrees with the horizontal. Where the maximum diameter of the nummuloidal segments is 22 mm., the constrictions at the septal necks narrow to 13 mm. In an annular zone 2 mm. in width surrounding these septal necks, the septa are in contact with the segments both above and beneath. This annular zone is concave in radial section when viewed from beneath. Exterior to this inner zone is a second annular zone, 3 mm. wide, along which the septa are in contact only with the lower side of the overlying segments of the siphuncle. The interior of the siphuncle is lined with calcareous deposits which do not reach the center.

Locality and Horizon.—From the drift at York Factory, at the mouth of the Nelson river; possibly from the Ordovician, but

the horizon is unknown. No. 311S in the Royal Ontario Museum of Paleontology.

42. **Armenoceras lowi** Sp. nov.

Plate IX, figs. 1, 2, 3

Only fragments of the siphuncle are at hand. The largest (fig. 1) is 89 mm. long, 38 mm. in diameter, and enlarges at the rate of 3 mm. in a length of 100 mm. The number of segments in this fragment averages 6 in a length equal to the diameter of the siphuncle, but several consecutive segments near the middle of the fragment occur at the rate of 7.5 segments in a corresponding diameter. Its segments slope downward at an angle of about 5 degrees with a horizontal plane, from the ventral toward the dorsal side of the siphuncle. No. 7905a. Holotype.

At the opposite extreme is a specimen 40 mm. in diameter, in which only slightly more than 5 segments occur in a length equal to the diameter of the siphuncle. In this specimen the segments are horizontal, compared with a vertical central axis of the siphuncle. A similar specimen has been sectioned so as to show the structure of the calcareous deposits filling the interior of the siphuncle. Nos. 7905b, d.

None of the fragments exceed 40 mm. in diameter, and the smallest has a diameter of 27 mm. Most fragments have segments which slope at an angle of 5 degrees with the horizontal, but others have strictly horizontal segments. This suggests that the siphuncle was central or nearly central in location. Vertical sections of the siphuncle indicate that the inner part of the septa, for a width of 2 mm., was adnate to the segment beneath, and for a greater width to the segment above. In the immediate vicinity of the septal necks, the inner margin of these septa curves downward at an angle of about 35 degrees with the horizontal.

Locality and Horizon.—Southern half of the west coast of Southampton; presumably in Silurian strata. Specimens No. 7905 a, b, c, d, e, in the collections of the Geological Survey of Canada.

Remarks.—Compared with typical *Armenoceras arcticum*

Troedsson, the number of segments of the siphuncle in a length equal to the diameter of the siphuncle is greater, decreasing in the holotype of the former species from 5 at its base to 4 along its upper part.

43. **Armenoceras inclinatum** Sp. nov.

Plate IX, fig. 4

Specimen differing from those represented by figures 1, 2, and 3 on the same plate chiefly in the greater obliquity of its segments, this equalling 13 degrees with the horizontal. This siphuncle evidently was distinctly excentric in location.

Locality and Horizon.—Southern half of west coast of Southampton; presumably in the Silurian. No. 7905-i in the collections of the Geological Survey of Canada.

44. **Armenoceras southamptonense** Sp. nov.

Plate IX, figs. 5, 6

Siphuncles with about 4 segments in a length equalling to their diameter; these segments slope downward at an angle of 13 degrees with the horizontal toward their dorsal sides.

Locality and Horizon.—Southern half of the west coast of Southampton Island; presumably in the Silurian. Nos. 7905-k, j, in the collections of the Geological Survey of Canada.

Remarks.—Compared with *Armenoceras arcticum*, the segments of the siphuncle slope more strongly downward in a ventrad direction, this slope equalling only 5 degrees, compared with the horizontal, in the former species.

45. **Armenoceras** sp. (Southampton)

Plate XIII, figs. 3 A, B

A small fragment of a small siphuncle, 26 mm. long and 14 mm. in diameter, not enlarging within this length; noteworthy chiefly on account of the small number of its segments within a length equal to its diameter, only 3 segments occurring in this length. The segments slope downward at an angle of 8 degrees with a horizontal plane, from the ventral toward the dorsal side of the siphuncle.

Location and Horizon.—Southern half of the west coast of Southampton island; in the Silurian. Collected by A. P. Low, and numbered 7906a in the collections of the Geological Survey of Canada.

Remarks.—Compared with *Armenoceras concinnum* Troedsson, the segments of the siphuncle slope distinctly downward, indicating that the siphuncle was not central in location, as in the former species.

46. **Armenoceras hearsti** (Parks)

Plate VIII, fig. 4; plate XXIV, fig. 5

Actinoceras hearsti Parks, Trans. Royal Canadian Inst., 11, 1915, p. 73, pl. 6, fig. 5.

Specimen 100 mm. long, including the siphuncle and the ventral side of the conch. The original diameter of the conch is estimated at 120 mm.; about 10 camerae occurred in a corresponding length. The sutures of the septa curve downward 6 mm. in a width of 70 mm. along the median part of the ventral side of the conch, the total depth of these ventral lobes probably equalling 10 mm. along the entire width of the conch. The siphuncle is 48 mm. in diameter, apparently enlarging but slightly within the length of the specimen at hand. Its ventral wall is 3 to 5 mm. from the ventral wall of the conch. Four segments occupy a length equal to this diameter. These segments slope downward toward the dorsal side of the conch at an angle of 10 degrees with the horizontal. The septal necks are 29 mm. in diameter. Along the dorsal side of the siphuncle these septal necks are half a millimeter in length, and ventrally they are narrowed to acute angles between successive segments. The septa are adnate to the lower faces of the overlying segments, but not to the upper faces of the underlying ones. Along the ventral side of the siphuncle the area of contact between the septa and the overlying segments is separable into relatively faint concave annular zones. The surface of the shell apparently was smooth.

Locality and Horizon.—Limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 314S in the Royal Ontario Museum of Paleontology.

Remarks.—*Armenoceras hearsti* differs from *Huroniella inflecta* chiefly in the absence of concave zoning along the lower part of the lateral and dorsal sides of the siphuncle, double concave zoning being nearly obsolete even along its ventral side. Moreover the septal necks are very short dorsally and are reduced to a mere angle between successive segments ventrally.

47. **Armenoceras severnense** Sp. nov.

Plate XI, figs. 4 A, B

Specimen 42 mm. long, consisting of 4 segments of a siphuncle, enlarging from a lateral diameter of 28 mm. to 30 mm. in a length of 22 mm. Three segments occur in a length equal to this diameter. The ventral side of the upper two segments shows areas of contact with the ventral wall of the conch. These areas are 20 mm. wide and 7 mm. in height, their lower margin presenting a lunate outline which fails to reach the top of the underlying segment by a height of nearly 3 mm. The segments slope in a dorsad direction at an angle of 10 degrees with the horizontal. The outer zone of contact between the septa and the overlying segments of the siphuncle present concave vertical outlines, the upper margins of which rise on passing from the dorso-lateral to the ventrolateral sides of the segments; on the dorsal side of the segments this concave vertical zone probably disappears entirely. In a corresponding manner, the annulations characterizing the individual segments occupy the entire height of these segments dorsally, but only their upper portion ventro-laterally. The septal neck at the base of the specimen is estimated at 16 mm. in diameter. Along the inner contact zone, the septum was in contact with both the segment above and that beneath.

Locality and Horizon.—Severn river; at horizon 10, in the Attawapiskat limestone. No. 31 HB in the Savage collection.

Remarks.—This specimen appears to have been similar to *Armenoceras altosegmentatum* Foerste, described from the Silurian in the Lake Timiskaming area. It is weathered in such a manner as to present vertical plates which radiate outward from the subcentral parts of the siphuncle. Similar structure is present in other Actinoceroids.

HURONIELLA Foerste

Genotype: *Huronia inflecta* Parks, Trans. Royal Canadian Inst., 11, 1915, p. 75, pl. 6, fig. 4; also this bull., pl. xi, figs. 1A, B.

Huroniella Foerste, Contributions Mus. Geol. Univ. Michigan., 2, 1924, pp. 39, 43; also Memoir 145, Geol. Surv. Canada, 1925, p. 81.

48. Huroniella inflecta (Parks)

Plate XI, figs. 1 A, B; 3

Huronia inflecta (Parks), Trans. Royal Canadian Inst., 11, 1915, p. 75, pl. 6, fig. 4.

Specimen 85 mm. long, consisting of 6 segments of a siphuncle, of which 3.5 segments occur in a length equal to the diameter of the siphuncle, the latter being 45 mm. No enlargement of the siphuncle can be detected in the length at hand. At the inner margin of the septal necks the siphuncle is contracted to a diameter of 27 mm. The septa are adnate to the lower face of the overlying segments. This area of contact is divisible into two annular zones, only slightly, but distinctly, concave in radial section when viewed from below. The inner one of these zones extends 4 or 5 mm. from the inner margin of the septal necks, and the outer zone extends 8 or 9 mm. farther, and rises with a steeper slope. The inner zone is in contact with the segment beneath as well as with the one above, the inner margin of the septal neck having no appreciable height. The outer zone is in contact only with the overlying segment, the septum becoming free from this overlying segment near mid-height of the segment, where the concave curvature of the outer zone meets the convex vertical outline of the annulation of the segment.

Locality and Horizon.—Limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 310S in the Royal Ontario Museum of Paleontology.

Pagwachuan specimen.—A similar specimen (fig. 3), but with less strongly sloping segments was found by Prof. M. Y. Williams about 8 miles above the mouth of the Pagwachuan river. The Pagwachuan is a southern tributary of the Kenogami river, the latter entering the Albany. The fossil locality is at 50°7′ N latitude and 84°48′ W longitude.

49. Huroniella subinflecta Sp. nov.

Plate VIII, fig. 2

Siphuncle nearly 80 mm. long, 41 mm. in diameter at its base, and not enlarging appreciably within the length at hand. Three and a half segments occur in a length equal to the diameter of the siphuncle. Two zones of contact between the septa and the immediately overlying segments of the siphuncle may be noted, both concave in cross-section when viewed from below. The inner zone, surrounding the septal neck, is 4 mm. in width, and is in contact with both the segment above and beneath. The outer zone is about 6 mm. in width, is in contact only with the overlying segment, and rises at a much steeper angle. The diameter of the septal neck at the base of the specimen is 25 mm. Here the inner margin of the septum curves moderately downward, but without turning outward at its basal margin. The segments slope at an angle of about 5 degrees with the horizontal.

Locality and Horizon.—Severn river; at horizon 10, in the Attawapiskat limestone. No. 32 HB in the Savage collection.

Remarks.—This specimen differs from typical *Huroniella inflecta* (Parks) in the smaller slope of its segments, and in the smaller concavity of the outer zone of contact of the septa with the overlying segments.

HURONIA Stokes

Genotype: *Huronia bigsbyi* Stokes, Trans. Geol. Soc. London, 2nd ser., 1, 1824, Expl. pl. 28; also Foerste, Contributions Mus. Geol. Univ. Michigan, 2, 1924, p. 42, pl. 4, fig. 1, pl. 11, fig. 1; Memoir 145, Geol. Surv. Canada, 1925, p. 78.

50. Huronia septata Parks

Plate XII, figs. 2, 1, 4

Huronia septata Parks, Trans. Royal Canadian Inst., 11, 1915, p. 27, pl. 5, fig. 8; also Foerste, Contributions Mus. Geol. Univ. Michigan, 2, 1924, p. 57, pl. 8, fig. 1; pl. 10, fig. 6.

Specimen 106 mm. long (fig. 1), including 7 segments of the siphuncle, enlarging from a lateral diameter of 35 mm. at its base to 37 mm. at its top. The tops of the segments are nearly horizontal. The upper parts of the segments are annular but

their lower parts present concave vertical outlines along which the septa are adnate to the overlying segments. The line along which the septa become free from the lower face of the segments rises from about one-third of the height of the segment above its base to half of the height on passing from the dorsal toward the ventral side of the conch. No contact area is present on this ventral side, and the siphuncle probably is located at a moderate distance from actual contact with the ventral wall of the conch, or is moderately excentric. About two and a half segments occur in a length equal to the diameter of the siphuncle.

Locality and Horizon.—Shamattawa river; at horizon 2, in the Shamattawa limestone. No. 33 HB in the Savage collection.

Second specimen.—Specimen 84 mm. long (fig. 4), including 7 segments, with segments which slope at an angle of 5 degrees with the horizontal. The surface of the specimen is moderately weathered, and the concavity of the outer contact zone between the septa and the overlying segments of the siphuncle is considerably less than in the preceding specimen. From the Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 34 HB in the Savage collection.

Type specimen.—The type, described in both of the publications cited above, and represented by figure 2 on plate XII of this bulletin, was obtained from the Shamattawa river, in the Shamattawa limestone.

STOKESOCERAS Foerste

Genotype: *Stokesoceras romingeri* Foerste, Contributions Mus. Geol. Univ. Michigan, 2, 1924, p. 77, pl. 9, figs. 6, 7, 4, 2, 3; pl. 8, figs. 3 A, B.

Stokesoceras Foerste, idem., p. 76; also Memoir 145, Geol. Surv. Canada, 1925, p. 81.

51. Stokesoceras cylindratum Sp. nov.

Plate XVIII, fig. 4

Specimen 51 mm. long, including 16 segments of the siphuncle. These enlarge from a dorso-ventral diameter of 9 mm. at the second segment above the base to 13 mm. at a point 27 mm. farther up, and then maintain about the same diameter for

18 mm. The siphuncle appears slightly compressed laterally, its lateral diameter being 12 mm. where the dorso-ventral one is 13 mm. The segments slope downward toward the dorsal side of the siphuncle at an angle of 8 degrees with the horizontal.

Locality and Horizon.—Ekwan river; at horizon 4, in the Ekwan limestone. No. 35 HB in the Savage collection.

Remarks.—*Stokesoceras cylindratum* resembles *Stokesoceras romingeri* Foerste in the slender growth of its siphuncle, but it does not continue to enlarge along the upper part of its length, and therefore has a different aspect.

52. **Stokesoceras** cf. **perobliquum** Foerste

Plate XIII, figs. 4 A, B

Cf. *Stokesoceras perobliquum* Foerste, Memoir 145, Geol. Surv. Canada, 1925, p. 84, pl. 11, fig. 6.

A small fragment of a siphuncle, rapidly enlarging, and slightly curved lengthwise. The lateral sides diverge at an angle of 13 degrees. Only 5 segments remain, and these slope downward in a dorsad direction at an angle of 25 degrees with a plane directly transverse to the curving vertical axis of the siphuncle. The interior of the siphuncle is filled with fibrous calcareous deposits, the fibers of which are at right angles to the walls of the siphuncle. At the base of the specimen these deposits occupy all but a small central tube-like space 1 mm. in diameter; but at its top, where the siphuncle is 14 mm. in diameter, this space has widened to a diameter of 4.5 mm.

Locality and Horizon.—Southern half of the west coast of Southampton Island; in the Silurian. Collected by A. P. Low, and numbered 7847 in the collections of the Geological Survey of Canada.

53. **Stokesoceras ekwanense** Sp. nov.

Plate VI, fig. 2; plate VII, fig. 3; plate XI, fig. 6

Siphuncle 150 mm. in length, flattened dorso-ventrally by pressure, enlarging laterally from 18 mm. at its base to 42 mm. at a point 115 mm. farther up. The number of segments in a

length equal to the lateral diameter at the top of the series counted is 6. The segments slope downward from the ventral toward the dorsal side of the siphuncle at an angle of 15 degrees with the horizontal. No. 36 HB.

Siphuncle 110 mm. long, flattened laterally; enlarging from a dorso-ventral diameter of 20 mm. at its base to 29 mm. at a point 57 mm. farther up. In other respects closely like the preceding. Neither specimen shows any contact area along the ventral side of the siphuncle. No. 37 HB.

Locality and Horizon.—Ekwan river; at horizon 2, in the Ekwan limestone. Nos. 36 HB and 37 HB in the Savage collection.

Severn river specimen.—Specimen 76 mm. long, apparently undistorted, 39 mm. in diameter laterally and 37 mm. dorso-ventrally at the base of the specimen, enlarging to a lateral diameter of 46 mm. at a point 55 mm. farther up. About 5.5 segments occur in a length equal to the diameter of the siphuncle. These segments slant at an angle of 15 degrees with the horizontal. The ventral side shows no trace of contact with the ventral wall of the conch. From horizon 7, in the Ekwan limestone. No. 38 HB in the Savage collection.

Remarks.—These specimens differ from *Stokesoceras engadinense* chiefly in their smaller apical angle of enlargement, and in the greater slant of their segments.

54. Stokesoceras (?) keewatinense (Whiteaves)

Actinoceras keewatinense Whiteaves, Geol. Surv. Canada, Pal. Foss., 3, pt. 4, p. 246, pl. 30, figs. 7, 8.

A fragment of a siphuncle 87 mm. long, enlarging from a diameter of 13.5 mm. at the base to 22 mm. at its top. Two and one-third segments occupy a length equal to the diameter of the siphuncle. The contraction of the segments of the siphuncle at their junction with the septa is small, compared with the diameter of these segments at mid-height. The inner part of these segments is in contact with both the segment above and that beneath for an annular width of 1.5 mm.

Locality and Horizon.—Rainy Island, in the Attawapiskat

River; presumably in the Attawapiskat limestone. In the collections of the Geological Survey of Canada.

Remarks.—This siphuncle is remarkable for the small extent to which the septum penetrates between the segment above and below, it being adnate to both. In this respect it differs from *Elrodoceras*.

DISCOSORUS Hall

Genotype: *Discosorus conoideus* Hall, Pal. New York, 2, 1852, p. 99, pl. 28, figs. 13 a-c; also Foerste, Contributions Mus. Geol. Univ. Michigan, 2, 1924, p. 67, pl. 7, figs. 1 A-C; Memoir 145, Geol. Surv. Canada, 1925, p. 85.

55. Discosorus parksi Sp. nov.

Plate XII, figs. 3 A, B, C, plate VIII, fig. 3, plate XXIII, fig. 8

Actinoceras sp., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 74, pl. 2, fig. 3.

Specimen consisting of two segments of a siphuncle and one side of a third segment. Its lateral diameter enlarges at an apical angle of 20 degrees, and the rate of enlargement of the siphuncle in a dorso-ventral direction probably was commensurate. The cross-section of the siphuncle probably was circular, but its segments slope downward from the ventral toward the dorsal side at an angle of 35 degrees with the horizontal, thus producing segments which appear elliptical in outline when viewed from above. Where the lateral diameter of basal segment is 44 mm., its dorso-ventral diameter is 56 mm.; the corresponding diameters of the second segment are 48.5 mm. and 60 mm.; and those of the third segment, as estimated from the small part preserved, are 53.5 mm. and 67 mm. Flattened areas along the ventral side of the annulations of the segments indicate where these segments were in contact with the ventral wall of the conch. Along the second segment, this area is over 30 mm. wide and fully 8 mm. high along its median part. The change in direction of slope of successive contact areas indicates that the ventral side of the conch was curved lengthwise convexly with a radius of about 100 mm., the dorsal side of the siphuncle having a corresponding concave curvature. The most prominent part of the annulation formed by each segment is below mid-height dorsally

and rises toward the upper third ventrally. At the septal necks the siphuncle is greatly constricted, the neck at the base of the specimen being 24 mm. wide and 39 mm. long dorso-ventrally. This neck is 2 mm. from the dorsal end of the overlying segment and 15 mm. from its ventral end. Dorsally, the margin of the second segment recedes about 7 mm. from the margin of the preceding segment, but ventrally it projects fully 15 mm. beyond the ventral margin of the first segment.

Locality and Horizon.—Ekwan river; at horizon 2, in the Ekwan limestone. No. 39 HB in the Savage collection.

Remarks.—Parks figured a similar specimen, from approximately the same horizon, at the Assina rapids on the Severn river. His specimen is numbered 313S in the Royal Ontario Museum of Paleontology.

56. **Discosorus troedssoni** Sp. nov.

Plate XI, figs. 2 A, B

Fragment of siphuncle consisting of 8 segments, of which the upper two are badly crushed and therefore omitted in the accompanying figures. The ventral side is faintly curved lengthwise in a convex direction. The lateral sides diverge at an angle of 14 degrees. The segments slope downward from the ventral toward the dorsal side of the siphuncle at an angle of 23 to 26 degrees with a horizontal plane. On their ventral sides the lower surface of successive segments is strongly oblique to the slope of the segments, and projects strongly backward. Evidently the siphuncle was almost in contact with the ventral wall of the conch. From 3 to 3.5 segments occupy a length equal to the lateral diameter of the upper one of the segments counted. The interior of the segments is occupied by a calcareous deposit, the fibrous structure of which is vertical to the walls of the siphuncle. At the base of the specimen this deposit reaches the center of the siphuncle, but at its top a central space, 10 mm. in width, remains free from calcareous deposits, though now occupied by matrix. The rate of enlargement of this siphuncle is less than usual in typical *Discosorus*, but its general aspect is similar to the siphuncle of that genus.

Locality and Horizon.—Southern half of the west coast of Southampton Island; in the Silurian. Collected by A. P. Low, and numbered 7906 in the collections of the Geological Survey of Canada. Named in honor of Prof. Gustaf T. Troedsson, in recognition of his notable contributions to the paleontology of the Arctic Ordovician cephalopods.

LOWOCERAS Gen. nov.

Genotype: *Lowoceras southamptonense* Foerste and Savage.

Siphuncle slowly enlarging, strongly curved lengthwise, and with very oblique segments, the connecting rings appearing more like thick and more or less flattened oblique bands than like strongly rounded annulations. The intervening grooves, corresponding in location to the septal necks, are relatively long and not very deep. Along the convexly curved side of the siphuncle the upper margin of the connecting rings is more or less angulate. The interior of the siphuncle is lined with a thick deposit of fibrous calcareous material as in *Discosorus,* and also in other curved actinoceroids.

57. **Lowoceras southamptonense** Sp. nov.

Plate XIII, figs. 2 A, B, C

Fragment of a siphuncle 67 mm. long, curved lengthwise, the radius of curvature of its convex ventral side being 90 mm. The fragment includes 7 segments of the siphuncle. These segments slope donward from the ventral toward the dorsal side of the siphuncle at an angle of 50 degrees with a plane directly transverse to the curving vertical axis of the siphuncle. The grooves separating the successive segments are nearly 2 mm. wide, and are abruptly delineated, though shallow dorsally and laterally. These grooves apparently represent the septal necks. The intervening connecting rings present remarkably flat vertical outlines, especially dorsally and laterally. Along the median part of their ventral sides, their upper margins are angulated; possibly the sutures of the septa here were elevated into similarly angulated saddles. The interior of the siphuncle is lined with

fibrous calcareous deposits which leave a very much elongated central funnel-like passage, scarcely 1 mm. in diameter at the base of the specimen, but widening to 14 mm. at its top, where the diameter of the siphuncle is 16 mm.

Locality and Horizon.—Southern half of the west coast of Southampton Island; in the Silurian. Collected by A. P. Low. No. 7846 in the collections of the Geological Survey of Canada. Named in honor of Dr. Low, the former director of the Geological Survey of Canada.

Remarks.—Whiteaves described a "rather large, slightly curved, subcylindrical siphuncle, with faint, oblique, and rather distant constrictions" from the limestone rapid on Fawn river, a branch of the Severn, whose relationship to the species here described can not be determined from the brief description offered. (Pal. Foss., Geol. Surv., Canada, vol. 3, pt. 4, 1906, p. 278.)

OOCERINA Foerste

Genotype: *Cyrtoceras lentigradum* Barrande, Syst. Sil. du Centre de la Boheme, 2, 1867, p. 599, pl. 137.

Oocerina Foerste, Denison Univ. Bull. 21, 1926, p. 321, pl. 34, figs. 2 A-D.

58. **Oocerina shamattawaense** Sp. nov.

Plate XV, figs. 2 A, B

Orthoceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 23 (first specimen only).

Specimen 60 mm. long, slowly enlarging, laterally compressed, slightly curved lengthwise. The radius of lengthwise curvature is 190 mm. The dorso-ventral diameter at the base of the specimen is 32 mm. and no perceptible enlargement is noted toward its top. The lateral diameter is estimated at 27 mm. The living chamber is 44 mm. long, and the 3 camerae still attached have a total length of 14 mm. The sutures of the septa curve strongly downward laterally, and rise 6 mm. higher dorsally and ventrally. Whether this is due to distortion is unknown. The middle of the septa curves 4 mm. farther downward than the lateral part of the sutures. The siphuncle is 7 mm. in diameter laterally, and its nearest part is 3 mm. distant from the ventral

wall of the conch. Its segments are obliquely nummuloidal in form, contracting to 5 mm., or even less, at the septal necks. The upper margin of the living chamber appears to be directly transverse, but this is not definitely known to be the original course of the aperture.

Locality and Horizon.—Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 333S-a in the Royal Ontario Museum of Paleontology.

59. **Oocerina (?) sp. (Shamattawa River)**

Plate XV, figs. 3 A, B

Meloceras sp. indet., Parks, Royal Canadian Inst., 11, 1915, p. 29.

Specimen consisting of the basal part of the living chamber with 9 camerae still attached; slightly compressed laterally, nearly circular in cross-section; moderately curved lengthwise. The lengthwise curvature is indicated by the accompanying figure. The dorso-ventral diameter enlarges from 23.5 mm. at the base to 32.5 mm. at the top of the phragmacone. The corresponding lateral diameters are estimated at 22.5 mm. and 31 mm. Ten camerae formerly occupied a length equal to the dorso-ventral diameter of the conch at the top of the series counted. The sutures of the septa are approximately horizontal along the lower part of the specimen, but rise distinctly in a ventrad direction on approaching the base of the living chamber. The siphuncle is not defined clearly. Its location is near the ventral wall of the conch, and apparently it was more or less nummuloidal in form.

Locality and Horizon.—Lower rapids of the Shamattawa river, in the Shamattawa limestone. No. 328S in the Royal Ontario Museum of Paleontology.

60. **Oocerina severnense Sp. nov.**

Plate XIV, figs. 2 A, B, C

Ooceras (?) sp. nov., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 76, pl. 3, fig. 4; pl. 6, fig. 3.

Part of a phragmacone, compressed laterally; slightly curved lengthwise, as indicated by the accompanying figures. The

dorso-ventral diameter enlarges from 20 mm. at its base to 25 mm. at its top, the corresponding lateral diameters being 16 mm. and 20 mm. The number of camerae in a length equal to the dorso-ventral diameter is 11. The sutures of the septa curve downward laterally half a millimeter. The siphuncle is 7.2 mm. in diameter laterally, contracting to 5 mm. at the septal necks. Its segments are nummuloidal in form. The ratio of the diameter of the siphuncle to that of the conch dorso-ventrally is 0.34 or one-third. The inner margin of the septa is in contact with the segments of the siphuncle, both above and below, for a width of three-fourths of a millimeter from the septal neck. The surface of the shell appears to have been smooth.

Locality and Horizon.—Limestone rapids on the Severn river; presumably from the Attawapiskat limestone, since the matrix contains a small fragment of some species of *Pycnostylus,* a genus not known at present to occur in the Ekwan limestone. No. 330S-a in the Royal Ontario Museum of Paleontology.

61. **Oocerina** sp. (Severn River)

Plate XIV, fig. 4

Ooceras (?) *sp.*, Parks, Trans. Royal Canadian Inst., 11, 1915, p. 76, pl. 6, fig. 8.

Specimen including a considerable part of the living chamber to which a part of the phragmacone still is attached; cross-section nearly circular, assumed to have been slightly compressed laterally; moderately curved lengthwise, as indicated by the figure published by Parks. The curved outline along the ventral side of the figure published in this bulletin is due to the obliquity of the section passing through the living chamber. This chamber apparently contracted slightly toward the top. At its base the dorso-ventral diameter is 32 mm. It is estimated that 11 camerae formerly occurred in a corresponding length. The diameter of the siphuncle equals 0.22 of the dorso-ventral diameter of the conch. Parallel to the septa, however, their diameter equals 7.8 mm., contracting to 4.5 mm. at the septal necks. The nearest part of the siphuncle is 1.5 mm. from the ventral wall of the conch. The surface of the shell is smooth.

Locality and Horizon.—Limestone rapids on the Severn river; presumably from the Attawapiskat limestone, since it is from the same locality as the preceding specimen. No. 3308-b in the Royal Ontario Museum of Paleontology.

Remarks.—Compared with *Oocerina severnense* this specimen has a more circular cross-section; the diameter of its siphuncle, compared with that of the conch, is smaller; and the center of this siphuncle is correspondingly nearer the ventral wall of the conch.

TUYLOCERAS Gen. nov.

Genotype: *Tuyloceras percurvatum* Foerste and Savage.

Conch strongly curved lengthwise and compressed laterally. Siphuncle large, with strongly nummuloidal segments, nearly in contact with the convexly curved ventral side of the conch. Aperture apparently open; no evidence of contraction here similar to that of *Antiphragmoceras* Foerste. Moreover, the conch is not flattened dorsally, and its cross-section is not subcuneate.

62. **Tuyloceras percurvatum** Sp. nov.

Plate XIII, figs. 1 A, B

Conch curved strongly lengthwise and compressed laterally. The radius of convex ventral curvature varies from 75 mm. along the lower half of the phragmacone to 90 mm. along the upper part of the specimen. At the smaller end of the specimen its dorso-ventral diameter is 22 mm., increasing to 47 mm. at mid-length of the phragmacone, and to 49 mm. at the top of the phragmacone, diminishing thence to 40 mm. at the aperture. At the base of the living chamber the lateral diameter is 31 mm. The cross-section here is oval, the ventral side being much more narrowly rounded than the dorsal one. The siphuncle apparently is in contact with the ventral wall of the conch. At 40 mm. from the base of the specimen, the dorso-ventral diameter of the siphuncle equals 28.5 per cent of that of the conch, increasing to 44 per cent along the upper half of the phragmacone.

Along the lower half of the phragmacone the segments of the siphuncle slant downward dorsally at an angle of 15 degrees with the horizontal, becoming directly transverse along the upper third of the phragmacone, and sloping downward ventrally at its top, when compared with the strongly curving vertical axis of the conch. The aperture of the living chamber is not preserved but is assumed to have sloped downward ventrally. The surface of the shell apparently was smooth.

Locality and Horizon.—Ekwan river; at horizon 2, in the Ekwan limestone. No. 40 HB in the Savage collection.

Remarks.—The cross-section of the conch of *Tuyloceras percurvatum* is similar to that of *Antiphragmoceras ulrichi* Foerste, but the latter is flatter dorsally, and its siphuncle is relatively smaller. The chief difference, however, is found in the aperture of the living chamber, that of the latter species being distinctly phragmoceroid, with a ventral hyponomic lip, and a trilobate dorsal margin.

BYRONOCERAS Gen. nov.

Genotype: *Byronoceras longidomum* Foerste and Savage

Conch moderately curved lengthwise, almost circular in cross-section, slightly depressed, with the siphuncle almost in contact with the ventral wall. Sutures of the septa straight and directly transverse to the length of the conch or rising moderately in a ventrad direction toward the upper part of the phragmacone. Segments of the siphuncle obliquely oval or globular, their obliquity being caused by their location near the ventral wall of the conch where the septa curve strongly downward toward their center.

63. **Byronoceras longidomum** Sp. nov.

Plate XXIV, figs. 3 A, B

Specimen 58 mm. long, of which 35 mm. belongs to the living chamber, and 23 mm. is occupied by 5 camerae. The lengthwise curvature of its convex-ventral outline has a radius of 70 mm. The specimen enlarges dorso-ventrally from 22 mm. at its base to 23.5 mm. at the base of the living chamber, retaining about

the same diameter as far as the aperture. The lateral diameter enlarges from 23 mm. at the base of the specimen to 25 mm. at the base of the living chamber, and to 26.5 mm. a little above mid-height of the latter, thence maintaining the same diameter as far as the aperture. Five camerae occupy a length equal to the dorso-ventral diameter of the conch. The sutures of the septa are nearly straight, but rise increasingly toward the ventral side of the conch on approaching the top of the phragmacone. The siphuncle is very close to the ventral wall of the conch. The segments are very oblique; were it not for this obliquity their form would be approximately globular. The septal necks are short and cyrtochoanitic. The aperture is open, circular, and directly transverse. The surface of the shell appears to have been smooth.

Locality and Horizon.—Port Byron, Illinois; in the Port Byron member of the Niagaran, directly over the Racine stratigraphically. No. 307 in the U. S. National Museum.

64. **Byronoceras (?) humei Sp. nov.**

Plate XVII, figs. 3 A, B

Poterioceras (?) *sp.*, Foerste, Geol. Surv. Canada, Bull. 44, 1926, p. 69, pl. 14, figs. 3 A, B.

Living chamber elongated, depressed dorso-ventrally, and curved lengthwise. The radius of curvature of the convex ventral outline is 30 mm., that of the dorsal side being 25 mm. The lateral diameter at the base of the chamber is 18 mm., and the dorso-ventral one is 15 mm. The height of the chamber is about 20 mm. Its maximum diameter is a short distance below the aperture where its lateral diameter is 21 mm. and its dorso-ventral one is 19 mm. The suture of the septum at its base is straight and directly transverse. The septum is rather strongly concave, especially in a dorso-ventral direction. The siphuncle is located close to the ventral wall of the conch, its center being 1.5 mm. distant from the latter.

Locality and Horizon.—From the Silurian on the west shore of the North Arm of Great Slave Lake, associated with *Pycnostylus*

guelphensis and *Pycnostylus elegans.* Collected by Dr. George S. Hume.

CRATEROCERAS Gen. nov.

Genotype: *Crateroceras raymondi* Foerste and Savage

Specimens consisting chiefly of the living chamber, circular in cross-section; with the ventral side of the chamber about 2 mm. taller than the dorsal one, thus suggesting that the conch was slightly curved lengthwise. Vertical outlines convex on all sides of the chamber. Hyponomic sinus very shallow, not over 1 mm. in depth in the genotype. In this specimen the siphuncle is about one-seventh of the diameter of the chamber at its base distant from its ventral side. Its segments are similar to those of *Amphicyrtoceras*, but shorter.

Compared with *Amphicyrtoceras*, the living chamber of *Crateroceras* is shorter, circular instead of depressed in cross-section, and most gibbous at mid-height of the living chamber rather than at its base. The rate of expansion of the lower part of the chamber suggests that the phragmacone was short, possibly not over 45 mm. in length in case of the genotype.

65. Crateroceras raymondi Sp. nov.

Plate XXIV, figs. 1 A, B

Living chambers circular in cross section, relatively short, their height varying from 0.74 to 0.94 of the diameter. Vertical outlines convex on all sides of the chamber, the rate of expansion of the lower half of the chamber suggesting that the complete conch was breviconic, and only slightly curved lengthwise, the location of the siphuncle being exogastric. The margin of the aperture is directly transverse, and curves very slightly downward ventrally, forming a broad but shallow hyponomic sinus. One of the living chambers still has 2 camerae attached, the larger of which is only 2 mm. in height. Either these 2 camerae represent the camerae developed at a gerontic state of growth, when the last formed camerae often are shorter than those immediately beneath, or all of the camerae of this species are relatively

short. The sutures of the septa are straight and directly transverse. In a specimen 30 mm. in diameter at the base of the chamber, the expanded part of the siphuncle is 3 mm. in diameter, and its nearest part is a little over 3 mm. from the ventral wall of the conch. The general form of the segments of the siphuncle is similar to that of *Amphicyrtoceras*, but relatively short and distinctly oblique. The surface of the shell is ornamented by low transverse bands, about 12 in a length of 10 mm. These bands are of slight elevation, and are broadly rounded and separated by very shallow grooves, but are readily visible on cross-illumination.

Locality and Horizon.—Wauwatosa, Wisconsin; in the Racine dolomite. No. 2201 in the Museum of Comparative Zoology at Harvard University. Also from Greenfield, Wisconsin. Named in honor of Prof. Percy E. Raymond, of Harvard University, who has contributed greatly to the development of American paleontology.

66. **Crateroceras (?) humei** Sp. nov.

Plate XVII, figs. 4 A, B

Rizoceras (?) *sp.*, Foerste, Geol. Surv. Canada, Bull. 44, 1926, p. 70, pl. 14, figs. 4 A, B.

Living chamber short and tumid, enlarging from a width of 18 mm. at the base to 22 mm. at a point 8 mm. farther up, contracting above this level to a point 15 mm. above the base. The aperture is not clearly defined, but at mid-height of the specimen there is a relatively strong line of growth which curves downward along the median part of the ventral side so as to suggest the former presence of a shallow hyponomic sinus here. The siphuncle is located close to the ventral wall of the conch. A single segment of the siphuncle projects beneath the base of the chamber; this is poorly preserved but appears to be cyrtochoanitic in structure. Considering the small size of the living chamber, the septum at its base is rather strongly concave.

Locality and Horizon.—From the Silurian at the southern end of the west shore of the North Arm of Great Slave Lake, in strata containing *Pycnostylus guelphensis* and *Pycnostylus elegans*. Collected by Dr. George S. Hume.

DIESTOCERAS Foerste

Genotype: *Gomphoceras indianense* Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, 1894, p. 137, pl. 7, figs. 3–5.
Diestoceras Foerste, Denison Univ. Bull., 20, 1924, p. 262.

67. Diestoceras sp. (Nelson River)

Plate XV, figs. 4 A, B

Specimen consisting of a rapidly enlarging phragmacone, including 6 camerae, and of the lower part of a living chamber, very much flattened by oblique lateral pressure. In its present condition, the lowest recognizable suture indicates a septum with a maximum diameter of 26 mm. and a minimum one of 22 mm. At one end of the maximum diameter there is a depression about 3 mm. in diameter which suggests the presence here of a siphuncle, thus locating the ventral side of the conch. At the top of the phragmacone, the dorso-ventral diameter is 60 mm., and the lateral one is estimated at 54 mm. The greatest interval between the base and top of the specimen, in the present condition of the specimen, is 32.5 mm., but this interval undoubtedly originally was greater. At present the smaller end of the phragmacone is displaced so far laterally, that the most compressed lateral side presents a concave vertical outline. Originally, the conch evidently enlarged rapidly along the phragmacone and then curved upward along the lower part of the living chamber, and possibly inward toward its top.

Locality and Horizon.—Nelson river; at horizon 3, in the Nelson limestone. No. 41 HB in the Savage collection.

Remarks.—The chief interest in this specimen is due to the fact that it appears related to *Diestoceras nobile* (Whiteaves) and *Diestoceras apertum* (Whiteaves), species from about the same horizon in Manitoba.

68. Diestoceras tyrrelli (Parks)

Plate XVI, figs. 1 A, B, C

Poterioceras tyrrelli Parks, Trans. Royal Canadian Inst., 11, 1915, p. 29, pl. 2, fig. 2.

Specimen consisting of a living chamber and of 9 camerae. Its dorso-ventral diameter enlarges from 35 mm. at its base to

49 mm. at the third camera below the living chamber, and then contracts to 37 mm. at the constriction which is a short distance beneath the aperture. The corresponding lateral diameters are 30 mm., 40 mm., and 23 mm. The contraction beneath the aperture may have been due to an annular deposit on the walls of the interior of the living chamber, rather than to a contraction involving the exterior of the shell. The convex lengthwise curvature of the ventral side of the conch is slightly greater than that of its dorsal side. The basal part of the inner wall of the living chamber shows the impression of the attachment ring, with its short vertical grooves. The sutures of the septa are directly transverse. The concavity of the septa is 5 mm. in the case of the basal one, and 9 mm. at the top of the phragmacone. The siphuncle is located close to the ventral wall of the conch. A poor exposure of one segment of the siphuncle within the camera at the base of the specimen indicates a short septal neck 2.7 mm. in diameter, and a connecting ring 3.5 mm. in diameter. At the base of the living chamber the septal neck is 4 mm. in diameter.

Locality and Horizon.—Lower rapids on the Shamattawa river; in the Shamattawa limestone. No. 320S in the Royal Ontario Museum of Paleontology.

Remarks.—A second specimen from the same locality and horizon presents a similar living chamber. At the third camera below the living chamber its dorso-ventral diameter is estimated at 56 mm. The living chamber is at least 50 mm. high, and the maximum contraction of the cast of its interior is located 37 mm. above its base.

CYRTOGOMPHOCERAS Foerste

Genotype: *Oncoceras magnum* Whiteaves, Trans. Royal Soc. Canada, 7, 1890, p. 79, pl. 15, fig. 1.
Cyrtogomphoceras Foerste, Denison Univ. Bull. 20, 1924, p. 267.

69. Cyrtogomphoceras nutatum Sp. nov.

Plate XVII, figs. 2 A, B

Specimen 150 mm. long; at present dorso-ventrally depressed, but originally laterally compressed, the distortion being due to

dorso-ventral pressure. The dorsal side of the conch is evenly convex lengthwise. The dorsal outline is relatively straight, but originally was gibbous along the upper part of the phragmacone and the lower part of the living chamber. At the base of the specimen this dorsal outline is moderately concave. The lateral diameter enlarges from 25 mm. at the base of the specimen to 78 mm. at the base of the living chamber and then decreases to 51 mm. at its aperture. In the present condition of the specimen, the sutures at the base of the chamber slope downward toward the ventral side of the conch at an angle of 30 degrees with the horizontal, the margin of the aperture sloping about 40 degrees. Apparently there is a hyponomic sinus along the median part of the ventral side of the aperture, but this part is indistinctly defined. At the base of the specimen the sutures rise ventrally; at the fifth camera above the base they are at right angles to the curving vertical axis of the conch; and above this point they rise increasingly in a dorsad direction on approaching the upper part of the phragmacone. The center of the siphuncle is located 4 mm. from the ventral wall where the dorso-ventral diameter of the conch is 21 mm. The septal neck at this point is 4 mm. in diameter.

Locality and Horizon.—Nelson river; at horizon 4, in the Nelson limestone. No. 42 HB in the Savage collection.

Remarks.—*Cyrtogomphoceras nutatum* differs from *Cyrtogomphoceras magnum* (Whiteaves) chiefly in the smaller size of the conch, and in the relatively smaller height of its camerae compared with the diameter of the conch.

70. **Cyrtogomphoceras (?) shamattawaense** Sp. nov.

Plate XIX, figs. 1 A, B

Specimen 90 mm. long, strongly depressed dorso-ventrally by pressure; originally probably compressed laterally. The lateral diameter enlarges from 47 mm. at its base to 59 mm. a short distance above the base of the living chamber and then diminishes to 47 mm. at the aperture, the vertical lateral outline being slightly concave along the upper part of this chamber. The margin of the aperture slopes downward strongly toward its

ventral side, its median part being occupied by a deep hyponomic sinus, which is poorly outlined. The camerae number 9.5 in a length equal to the lateral diameter of the conch. The sutures of the septa are almost directly transverse, except at the top of the phragmacone where they rise slightly dorsally. Where the dorso-ventral diameter, in the present depressed condition of the specimen, is 35 mm., the center of the siphuncle is 3 mm. from the ventral wall of the conch. The diameter of the septal neck is 5 mm. laterally, the area of contact of the septum with the overlying segment of the siphuncle equalling 8 mm. laterally, the segment being enlarged within the camerae, though its exact form remains unknown.

Locality and Horizon.—Shamattawa river; at horizon 1, in the Shamattawa limestone, 7 miles up stream from the main exposure of this horizon. No. 43 HB in the Savage collection.

Remarks.—In *Cyrtogomphoceras intermedium* (Whiteaves) the ventral vertical outline is gently concave; the dorsal outline is most concave about 6 camerae below the base of the living chamber; and the conch enlarges more rapidly along the lower part of the phragmacone, and contracts more evenly along the upper part of the phragmacone and along the living chamber.

PROTOPHRAGMOCERAS Hyatt

Genotype: *Cyrtoceras murchisoni* Barrande, Syst. Sil. Centre Boheme, 2, 1867, p. 687, pls. 148, 160, 165, 176, 200.

Protophragmoceras Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 532, fig. 1086; also Foerste, Denison Univ. Bull., 21, 1926, p. 344, pl. 37, figs. 1 A-D.

In typical *Protophragmoceras*, the segments of the siphuncle are nummuloidal or vertically depressed in form. In the species here referred provisionally to this genus the segments are cylindroid in form, enlarging only slightly within the camerae. These Ekwan river species evidently are not strictly congeneric, but they agree at least to the extent of having the location of the siphuncle endogastric, and of showing no contraction of the living chamber toward its aperture, as far as this living chamber is known.

71. Protophragmoceras (?) boreale Sp. nov.

Plate XIV, figs. 5, 6

Specimen 28 mm. long; laterally compressed; curved lengthwise, with the siphuncle located almost in contact with the concave side of the conch. The radius of curvature of the convex dorsal side is 33 mm. The dorso-ventral diameter enlarges from 6 mm. at its base to 13 mm. at its top. The corresponding lateral diameters are 4.7 mm. and 11 mm. At the top of the phragmacone, where the dorso-ventral diameter is 12 mm., two camerae occupy a total height of 3 mm. dorsally. The sutures of the septa here curve downward laterally about the height of one camera. Where the dorso-ventral diameter of the conch is 10 mm., the diameter of the siphuncle is 0.7 mm., and its distance from the ventral wall of the conch is about one-fourth of a millimeter. The enlargement of the siphuncle within the camerae is slight. The surface of the shell is ornamented by transverse bands, of which 20 occur in a length of 10 mm. along the middle third of the specimen. These bands curve slightly downward laterally and also ventrally, but their course dorsally is unknown, though here also there might be a slight downward curvature.

Locality and Horizon.—Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 44 HB in the Savage collection.

Whiteaves specimen.—At the falls of the Ekwan river, at the same horizon, a specimen was found which is represented by fig. 3 on plate 34 of Paleozoic Fossils, Geol. Surv. Canada, vol. 3, pt. 4, 1906, erroneously referred to *Phragmoceras lineolatum* by Whiteaves. This specimen is represented also by fig. 6 on plate 14 of the present bulletin. It shows a downward curvature of the transverse bands both dorsally and ventrally. In this specimen 22 bands occur in a length of 10 mm. No. 4405 in the collections of the Geological Survey of Canada.

Remarks.—The specimens here described are referred to *Protophragmoceras* tentatively, chiefly to avoid the erection of a new genus on such insufficient material. They differ from typical *Protophragmoceras* chiefly in the small dilation of the segments

of the siphuncle within the camerae, the segments in the latter genus being nummuloidal.

72. **Protophragmoceras** (?) sp. (Ekwan River)

Plate V, fig. 9

Specimen 27 mm. long, compressed laterally, slightly curved lengthwise, the location of the siphuncle being endogastric. The lengthwise curvature of the conch is inferred from the fact that the transverse bands on the surface of the shell are slightly more distant from each on that side of the conch which is most remote from the siphuncle, especially when the directions of the bands at top and bottom of the specimen are compared. For this reason, also, the side nearest the siphuncle is regarded as slightly concave lengthwise, and the location of the siphuncle as endogastric. At the base of the specimen its dorso-ventral diameter is 17 mm., and its lateral one is 14.5 mm. The suture of the septum at the base of the specimen curves downward laterally 15. mm., the central part of the septum curving 2 mm. farther. The siphuncle is 1 mm. in diameter at the septal neck, but enlarges to 1.2 mm. within the camerae, its segments being nearly cylindrical. The surface of the shell is banded transversely, 12 bands occurring within a length of 10 mm. along the upper half, and 15 bands along a corresponding length in the lower half. Laterally these bands curve downward slightly less than 1 mm.; dorsally and ventrally they curve downward approximately an equal distance but along a narrower width.

Locality and Horizon.—Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 45 HB in the Savage collection.

Remarks.—This specimen evidently is closely related to *Protophragmoceras boreale*. All but the basal part of this specimen appears to belong to the living chamber. If that is the case, this living chamber shows no contraction at its upper end within the length at hand, and to that extent resembles *Protophragmoceras*, though different in the more cylindrical form of the segments of its siphuncle. Apparently this specimen was much less curved lengthwise than typical *Protophragmoceras boreale*.

73. **Protophragmoceras** (?) sp. (Ekwan River)

Plate XXIII, figs. 3 A, B; 4 A, B

Living chamber 30 mm. long, laterally compressed, curved lengthwise, with the siphuncle apparently endogastric in location. The radius of curvature of the convex dorsal side is estimated at 80 mm.; that of the concave ventral side varies from 25 mm. along the lower part of the chamber to 35 mm. farther up. The dorso-ventral diameter enlarges from 20 mm. at the base to an estimated diameter of 39 mm. at the aperture, the corresponding lateral diameters being 16 mm. and 33 mm. However, the aperture is not preserved, but is restored in conformity with the neighboring parts of the chamber. Apparently the upper parts of this chamber do not contract as in *Phragmoceras*. Along the lower part of the chamber the shell is fully 0.7 mm. thick, thinning to about 0.4 mm. toward the top. The surface of the shell is striated transversely, these striae curving downward along the convex dorsal side as far as in typical *Phragmoceras*. These striae number about 10 in a length of 5 mm. dorsally. Apparently there is a trace of a siphuncle only 0.5 mm. wide at the septal neck, 1.5 mm. distant from the concave ventral wall of the conch. If this identification of the siphuncle is correct, the latter probably does not have nummuloidal segments, as in typical *Protophragmoceras*.

Locality and Horizon.—Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 46 HB in the Savage collection.

Second specimen.—A second specimen, from the same locality and horizon, numbered 47 HB in the Savage collection, appears to enlarge less rapidly toward the aperture. At the base of the chamber is a single camera, 3 mm. in height dorsally. No trace of the siphuncle remains.

PHRAGMOCERAS Broderip

Genotype: *Phragmoceras arcuatum* Sowerby, in Murchison's Silurian System, 1839, p. 621, pl. 10, fig. 1 A; also Blake, British Fossil Cephalopoda, 1882, p. 204, pl. 26, figs. 1, 1 A; Foerste, Denison Univ. Bull., 21, 1926, p. 350, pl. 48, figs. 1 A, B.

74. Phragmoceras severnense Sp. nov.

Plate XIX, figs. 2 A, B

Living chamber 22 mm. in height at the dorsal end of the narrowly linear part of the aperture, presenting a relatively globose appearance. The dorso-ventral diameter increases from 19 mm. at the base of the chamber to 21.5 mm. at a line connecting the base of the hyponomic lip with the base of the neck supporting the dorsal lobe of the aperture. Laterally the diameter increases from 16 mm. at the base of the chamber to 19 mm. at mid-height. The lower margin of the dorsal neck is 12 mm. above the base of the chamber. This neck is 5 mm. long dorsally, and slopes obliquely backward. The dorsal lobe of the aperture is 12 mm. wide and 8 mm. long dorso-ventrally. On each side of the median part of its ventral margin, this dorsal lobe is indented. Along its median line it connects with the narrowly linear part of the aperture by a Y-shaped junction. This narrowly linear part slopes in a ventrad direction at an angle of 15 degrees with the horizontal. The hyponomic lip projects outward from the dorsal end of the aperture in the form of a short abrupt spout. The top of the chamber, viewed from above, is relatively globose. The siphuncle is located close to the ventral margin of the conch, and apparently is 2.5 mm. in diameter at the septal neck. The suture of the septum at the base of the living chamber is only slightly curved downward, the septum curving downward 2.5 mm. at its center. The surface of the shell is marked by relatively obscure transverse lines of growth which curve downward only moderately dorsally and ventrally.

Locality and Horizon.—Severn river; at horizon 2, in the Severn limestone. No. 48 HB in the Savage collection.

75. Phragmoceras nelsonense Parks

Plate XIX, figs. 3, 4, 5 A, B, 6

Phragmoceras nelsonense Parks, Trans. Royal Canadian Inst., 11, 1915, p. 83, pl. 1, fig. 7; pl. 3, figs. 1, 2.

Selected type.—Conch (fig. 3 on plate XIX of this bulletin) strongly curved lengthwise. The dorsal and ventral outlines

are indicated in the figure here cited. The dorso-ventral diameter increases from 13 mm. at the base to 26 mm. at the top of the phragmacone, and to 30 mm. along a line connecting the base of the ventral spout-like projection of the aperture with the base of the dorsal neck supporting the dorsal lobe of this aperture. The lateral diameter increases from 19 mm. at the base of the chamber to 22 mm. at a point 10 mm. farther up, and then decreases to 17 mm. at a point 22 mm. above the base of the chamber, above which the lateral walls of the chamber converge rapidly, approaching to within 1 mm. of each other along the narrowly linear part of the aperture. The latter slopes downward in a ventrad direction at an angle of 25 degrees with the horizontal. Both the ventral outline and the upper part of the dorsal outline slope slightly forward. The dorsal lobe of the aperture is similar to that of *Phragmoceras nestor*. The sutures of the septa are straight, and incline at various angles compared with the curving vertical axis of the conch.

Locality and Horizon.—From the drift near the entry of Seal river into Nelson river; probably from the Ekwan limestone. No. 316S in the Royal Ontario Museum of Paleontology.

Additional specimens.—The original of figure 1 on plate 7 published by Parks is not so strongly geniculate as the type here selected. The original of fig. 2 on the same plate has a closely similar living chamber, but the suture of the septum at its base curves downward more strongly laterally. A fourth specimen, not figured by Parks, is used for fig. 6 on pl. XIX in the present publication. All are from the same locality and horizon as the type, and bear the same serial number in the Royal Ontario Museum of Paleontology.

76. **Phragmoceras** sp. (Severn River)

Plate XX, fig. 4

Phragmoceras lineolatum Parks, Trans. Royal Canadian Inst., 11, 1915, p. 78.

Living chamber with almost all of the aperture missing, retaining only the spout-like projection at its ventral end. The ventral outline of this chamber is comparable with that of

Phragmoceras severnense and *Phragmoceras nelsonense*, in which the spout-like termination of the aperture projects abruptly forward. Compared with these species, however, the living chamber of the specimen described here is relatively lower. The dorso-ventral diameter at its base is 67 mm., and the lateral one is estimated at 45 mm. The sutures of the septa of the 2 camerae at its base curve distinctly downward laterally.

Locality and Horizon.—Limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 317S in the Royal Ontario Museum of Paleontology.

77. **Phragmoceras parksi** Sp. nov.

Plate XXI, figs. 1 A, B

Lower part of living chamber and 10 camerae of the phragmacone still attached. The length along its dorsal side is 117 mm. The radius of convex curvature along this side varies from 80 mm. along the phragmacone to 125 mm. along the living chamber. The dorso-ventral diameter enlarges from 50 mm. at the base to 98 mm. at the top of the phragmacone and 125 mm. at the highest part of the living chamber preserved. The radius of curvature of the concave ventral side is 30 mm. along the phragmacone. The ventral side of the living chamber slopes forward at an angle of 30 degrees with the perpendicular, curving distinctly backward at its top just before reaching the base of the hyponomic spout, which is not preserved. The dorsal outline slopes backward at an angle of 15 degrees with the perpendicular. The suture of the septum at the base of the living chamber is straight, though those of the underlying septa curve slightly downward. At the base of the living chamber, where the dorso-ventral diameter is 98 mm., the lateral one is 54 mm. This maximum lateral diameter is located 35 mm. from the dorsal wall, or dorsad of the center of the conch. Ventrad of this point, the lateral sides converge distinctly, so that the ventral part of the cross-section is rounded more narrowly than the dorsal part. The basal part of the interior of the living chamber had an attachment ring 10 mm. in height, vertically grooved. The surface of the shell is

striated transversely; dorso-laterally these striae cross the sutures at an angle of 35 degrees. The siphuncle is located close to the ventral outline of the conch. Its segments are broad, short, nummuloidal, and about 8 mm. wide at mid-length of the phragmacone. The shortness of the camera immediately beneath the living chamber indicates that the conch was mature.

Locality and Horizon.—Severn river; at horizon 10, in the Attawapiskat limestone. No. 49 HB in the Savage collection.

Remarks.—Compared with *Phragmoceras whitneyi*, this Severn river specimen enlarges much more rapidly dorso-ventrally especially along the living chamber, and this chamber is of smaller height.

78. **Phragmoceras cameroni** Sp. nov.

Plate XVII, figs. 1 A, B

Phragmoceras sp. Foerste, Geol. Surv. Canada, Bull. 44, 1926, p. 68, pl. 14, figs. 2 A, B.

Specimen including a cast of the interior of the living chamber; also a cast of the exterior of one side of this chamber and of the immediately adjacent part of the phragmacone. Height of chamber 22 mm., dorso-ventral diameter 21 mm., lateral diameter 20 mm. As far as can be determined from the specimen at hand, its aperture consists of a relatively large and approximately circular lobe and of a much narrower but relatively short ventral lobe. This ventral lobe may have extended forward in the form of a spout-like projection, but no trace of this remains. The base of the cast of the interior of the chamber retains an impression of the annular attachment ring, marked by short vertical grooves, 11 grooves in a width of 10 mm.

Locality and Horizon.—West shore of North Arm of Great Slave Lake; associated in the same strata with *Pycnostylus guelphensis* and *Pycnostylus elegans*, from which it is concluded that their horizon was about the same as that of the Attawapiskat limestone. Collected by Dr. George S. Hume. Named in honor of A. E. Cameron, one of the investigators of the geology of Great Slave Lake.

Remarks.—This species is characterized by the slight backward slope of both the ventral and dorsal vertical outlines of its living chamber.

79. **Phragmoceras lineolatum** Whiteaves

Plate XX, figs. 3 A, B; 1

Phragmoceras lineolatum Whiteaves, Pal. Foss., Geol. Surv. Canada, vol. 3, pt. 4, 1906, p. 265, pl. 34, fig. 2 (not figs. 1, 3).

Type.—Conch strongly curved lengthwise, enlarging rapidly dorso-ventrally, but only moderately laterally; dorsal lobe of aperture apparently rounded, somewhat as in *Phragmoceras nestor*. The radius of curvature of the dorsal outline of the conch changes from 27 mm. along the phragmacone to 45 mm. along the living chamber. The dorso-ventral diameter enlarges from 6 mm. at the base to 28.5 mm. at the top of the phragmacone and about 45 mm. at a line connecting the base of the dorsal neck with the base of the hyponomic spout; above this level the spout projects strongly forward. The lateral diameter increases from 5 mm. at the base to 19 mm. at the top of the phragmacone, and 24 mm. at mid-height of the living chamber, above which level it contracts at a relatively moderate rate toward the narrowly linear part of the aperture. The latter slopes in a ventrad direction at an angle of 30 degrees with a plane parallel to the base of the chamber. The sutures of the septa curve only moderately downward laterally, becoming more nearly horizontal dorsally and ventrally. The surface of the shell is crossed by transverse striae, 14 to 18 in a length of 5 mm. These striae belong to the banded type of structure characteristic of *Geisonoceras*. They curve strongly downward dorsally, and less conspicuously ventrally.

Locality and Horizon.—Falls of Ekwan river; from the Attawapiskat limestone. No. 4404 in the collections of the Geological Survey of Canada.

Remarks.—Of the three specimens figured by Whiteaves under *Phragmoceras lineolatum*, the second here is selected as the type, since it presents the greatest detail in structure. The

specimen figured first does not retain the surface ornamentation giving rise to the specific name.

Savage specimen.—Living chamber 32 mm. in height, 24 mm. in diameter dorso-ventrally and 16 mm. wide at its base, similar in form to typical *Phragmoceras lineolatum.* The dorsal lobe of the aperture is 14 mm. wide and 12 mm. long dorso-ventrally; its junction with the narrowly linear part of the aperture is abrupt. The dorsal neck is preserved for a height of 3 mm., its original height being unknown. The ventral outline evidently rounded gradually into the basal outline of the hyponomic spout. Along the upper half of the chamber 27 transverse striae occupy a length of 10 mm. From Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 50 HB in the Savage collection.

80. Phragmoceras whiteavesi Sp. nov.

Plate XX, fig. 2

Phragmoceras lineolatum Whiteaves, Pal. Foss., Geol. Surv. Canada, vol. 3, pt. 4, 1906, p. 265, pl. 34, fig. 1 (not figs. 2, 3).

The large living chamber figured by Whiteaves under *Phragmoceras lineolatum* differs from that forming part of his second specimen, here selected as the type, in its much larger size, and in the much stronger downward curvature of the suture of the septum at its base. The lateral sides of this chamber are of such small convexity as to appear almost parallel when viewed from above. The linear part of the aperture is remarkably wide, equalling 8 or 9 mm. in width for a dorso-ventral length of at least 45 mm. The lower margin of the dorsal neck is not indicated clearly, but this neck appears to have been compressed laterally, in conformity with the remainder of the chamber. The specimen is a cast of the interior and does not exhibit any trace of the ornamentation of the surface of the shell.

Locality and Horizon.—Middle rapid of the falls of the Ekwan river; in the Attawapiskat limestone. No. 4405a in the collections of the Geological Survey of Canada.

81. Phragmoceras whitneyi Parks

Plate XXII, fig. 1

Phragmoceras whitneyi Parks, Trans. Royal Canadian Inst., 11, 1915, p. 77, pl. 3, fig. 5; pl. 6, fig. 2.

Living chamber about 165 mm. in height, strongly compressed laterally, especially at its base, where the dorso-ventral diameter is 110 mm. and the lateral diameter is estimated at 40 mm. Here the suture of the septum curves 23 mm. downward laterally, its maximum curvature being ventrad of the center of the conch. At 90 mm. above the lowest part of the suture the lateral diameter of the chamber has increased to 54 mm., converging above this point toward the aperture. The ventral and dorsal outlines are shown in the accompanying figure. A faint groove 113 mm. above the dorsal end of the septum at its base appears to indicate the location of the base of the dorsal neck. The dorsal lobe of the aperture is missing, but its general outline is supposed to be somewhat similar to that of *Phragmoceras nestor*, connecting in a Y-shaped manner with the narrowly linear part of the aperture. The latter slants downward in a ventrad direction at an angle of 35 degrees with a plane passing through the dorsal and ventral ends of the septum at the base of the chamber.

Locality and Horizon.—Limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 318S in the Royal Ontario Museum of Paleontology.

Remarks.—Compared with *Phragmoceras ellipticum* Hall and Whitfield, the living chamber of the Severn river specimen is much larger, the suture at the base of this chamber curves downward laterally much more strongly, and the ventral outline curves more strongly forward.

Unfortunately the phragmacones from the Ekwan limestone at the Assina rapids on the Severn river, referred by Parks to *Phragmoceras whitneyi*, preserve no trace of the siphuncle, notwithstanding the fact that the septa are well preserved along that side of the phragmacones which is curved concavely lengthwise, and therefore should at least preserve the passage of the

siphuncle through the septa. Similar specimens collected by Prof. Savage and Tuyl show similar features. Hence their reference to *Phragmoceras* can not be considered as established, though their general appearance is similar to that of a phragmoceroid phragmacone.

82. Phragmoceras sp. (Ekwan River)

Plate XVI, figs. 3 A, B

Lower part of a living chamber, strongly compressed laterally and curved lengthwise. The radius of curvature of the convex dorsal outline is 30 mm., that of the concave ventral side is 10 mm. for a distance of 5 mm. from the base, above which this side is not preserved. At this base, the dorso-ventral diameter is 18.5 mm., and the lateral one is 12 mm. The lateral sides converge moderately in a dorsad direction. The chamber enlarges rather rapidly in a dorso-ventral direction. The suture of the septum at the base of the chamber curves downward 2 mm. laterally, resulting in distinct dorsal and ventral saddles. The surface of the shell is crossed transversely by relatively broad bands, of which 7 occur in a length of 10 mm. along the dorsal outline of the chamber. These bands are similar to those of *Geisonoceras*. These bands curve strongly downward dorsally, but only slightly ventrally. That band crossing the dorsal side of the conch at the base of the living chamber crosses its ventral side fully 5 mm. above this base. Three or four weakly defined striae occur within the limits of each of these bands.

Locality and Horizon.—Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 51 HB in the Savage collection.

83. Phragmoceras vantuyli Sp. nov.

Plate XXI, figs. 2 A, B

Specimen 59 mm. in height, erect, presenting a cuneate outline on lateral view; strongly compressed laterally. The ventral outline is straight, except along the hyponomic spout-like projection. The dorsal outline is slightly concave, except along the dorsal neck supporting the dorsal part of the aperture. The

living chamber is 35 mm. in height. At its base the dorso-ventral diameter is 29 mm. and the lateral one is 19 mm. The dorsal lobe of the aperture is similar to that of *Phragmoceras nestor* in outline, joining the narrowly linear part of the aperture at a Y-shaped junction. This linear part slopes downward in a ventrad direction at an angle of 15 degrees with the horizontal. The hyponomic spout-like projection is not preserved in the specimen at hand. The uppermost 3 camerae occupy a total length of 10.5 mm. The suture at the base of the living chamber curves downward only slightly laterally. The siphuncle is 2.7 mm. in diameter at the top of the phragmacone and its nearest part is half a millimeter from the ventral wall of the conch. At the septal neck, the diameter of the siphuncle is constricted to 2 mm., its segments being fusiform, instead of nummuloidal, in shape. The surface of the shell is striated transversely, 22 striae occupying a length of 10 mm. along the upper part of the lateral sides of the living chamber. They curve gently downward dorsally, and more abruptly ventrally.

Locality and Horizon.—Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 52 HB in the Savage collection.

Remarks.—This Ekwan river specimen resembles *Phragmoceras anticostiense* Foerste, from the Chicotte formation in its erect cuneate outline when viewed from one of the lateral sides, though smaller in size, and with a relatively taller living chamber.

GOMPHOCERAS Sowerby

Genotype: *Orthoceras pyriforme* Sowerby, in Murchison's Silurian System, 1839, p. 620, pl. 8, fig. 19 (upper fig. only); also Blake, British Fossil Cephalopoda, 1882, p. 192, pl. 22, figs. 2, 2A; Foerste, Denison Univ. Bull., 21, 1926, p. 353, pl. 49, figs. 1 A, B; 2 A, B.

84. Gomphoceras (?) sp. (Severn River)

Gomphoceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 79.

Living chamber 27 mm. in height in its present condition, 51 mm. in diameter dorso-ventrally, and a little less laterally. The walls of this chamber converge strongly toward the aperture from every side. Apparently there is a trace of a hyponomic

sinus, but not of the dorsal part of the aperture. Hence it is impossible to determine the generic relations of this specimen. Evidently it is not congeneric with *Gomphoceras pyriforme* Sowerby.

Locality and Horizon.—Above the limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 331S in the Royal Ontario Museum of Paleontology.

PENTAMEROCERAS Hyatt

Genotype: *Gomphoceras mirum* Barrande, Syst. Sil. Centre Boheme, 2, 1867, p. 319, pls. 82, 91.

Pentameroceras Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1883, p. 278; also Foerste, Denison Univ. Bull., 21, 1926, p. 356, pl. 50, figs. 6 A-C.

85. Pentameroceras rarum Parks

Plate XXIII, figs. 7 A, B, C

Pentameroceras rarum Parks, Trans. Royal Canadian Inst., 11, 1915, p. 78, pl. 3, fig. 6.

Specimen consisting of the living chamber and a small part of the phragmacone. A broad, faint, transverse groove, 16 mm. below the top of the specimen, probably locates the attachment ring at the base of the inner wall of the chamber, from which the height of this chamber is estimated at 17 mm. At the base of this chamber its dorso-ventral diameter is 16 mm., and the lateral one is 14.5 mm. Three or four millimeters farther up the corresponding diameters are 17 mm. and 15.2 mm., above which the conch contracts rapidly, especially laterally. The narrowly linear part of the aperture slopes downward ventrally at an angle of 40 degrees with a horizontal plane, terminating at an abrupt spout-like projection at least 1 mm. long, and 9 mm. above the base of the chamber. From the dorsal end of this linear part of the aperture 5 narrow lobes radiate, of which the middle one is shorter than the rest and is directed backward. The other 4 lobes vary from 5 to 6 mm. in length, one pair being directed laterally and the other pair antero-laterally. The surface of the shell is striated transversely, 8 to 10 striae in a length of 2 mm. along the middle of the lateral sides. Ventrally

they curve downward about 3 mm., while dorsally they remain almost horizontal.

Locality and Horizon.—Above the limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 324S in the Royal Ontario Museum of Paleontology.

86. **Pentameroceras (?) sp. (Severn River)**

Plate XXIII, figs. 6 A, B, C

Ooceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 76 (first specimen only).

Living chamber 13 mm. high. At its base the dorso-ventral diameter is 12 mm. and the lateral one is 10 mm. Four millimeters above the base the dorso-ventral diameter increases to 13 mm., above which the chamber contracts, at first gradually, and then more rapidly in the immediate vicinity of the aperture. Only one part of the aperture is clearly defined, and that is its ventral part, consisting of the narrowly linear part of the aperture and of the basal part of the hyponomic spout-like prolongation with which the aperture terminates ventrally. In the present case the base of this spout-like projection is circular and is slightly larger than the width of the linear part of the aperture. The dorsal part of the aperture is too poorly preserved to determine definitely the generic relations of the specimen. Apparently there is a single posterior lobe, directed backward. There also are several lateral lobes, but their number can not be determined. A trace of the siphuncle is present on the ventral side of the septum at the base of the chamber.

Locality and Horizon.—Limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 336S-a in the Royal Ontario Museum of Paleontology.

Remarks.—In the absence of definite knowledge as to the number of lobes at the posterior end of the aperture it is impossible to determine the generic relations of this specimen with confidence, but the general form of this living chamber is similar to that of an undoubted specimen of *Pentameroceras* from a quarter of a mile north of the Bacon Flat school in Adams county,

Ohio, at a horizon corresponding approximately to the Guelph of Canada.

OCTAMEROCERAS Hyatt

Genotype: *Octameroceras callistomoides* Foerste separated from *Phragmoceras callistoma* Barrande, Syst. Sil. Centre Boheme, 2, 1867, p. 234, pl. 67, figs. 3, 4, 7.

Octameroceras Hyatt, in Zittel-Eastman's Text-book of Paleontology, 1900, p. 531; see also Foerste, Denison Univ. Bull., 21, 1926, p. 363, pl. 50, figs. 4 A-C.

87. **Octameroceras walkeri** Sp. nov.

Plate XXIII, figs. 5 A, B

Septameroceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 79.

Living chamber 11 mm. high, with a lateral diameter of 12 mm., the dorso-ventral diameter being estimated at 14 mm. The dorsal and ventral vertical outlines are indicated by the second figure cited above, the ventral outline being on the left. The lateral outlines converge at an angle of 35 degrees along the lower part of the chamber, but curve more rapidly inward on approaching the narrowly linear part of the aperture. This linear part slopes downward ventrally at an angle of 35 degrees with the horizontal. Its length is 5 mm., and it terminates ventrally in a slightly enlarged rounded area which is the only part remaining of the former spout-like prolongation of the aperture at its hyponomic sinus. The dorsal part of the aperture is broadly triangular in shape, but with 4 pairs of lateral lobes. Its posterior margin has a lateral diameter of 7.5 mm., and a dorso-ventral length of slightly over 4 mm. Along this posterior margin, the upper part of the dorsal wall of the chamber rises upward and curves forward, thus resulting in a concave outline along the dorsal margin of the aperture.

Locality and Horizon.—From a loose boulder at the limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 327S in the Royal Ontario Museum of Paleontology. Named in honor of Prof. Thomas L. Walker of the University of Toronto, in memory of pleasant days spent on the geology of Manitoulin island.

A. **Zaphrentis (?)** sp. (Severn River)

Orthoceras (?) *sp. indet.*, **Parks, Trans. Royal Canadian Inst., 11, 1915, p. 72.**

Fragment resembling the upper part of a zaphrentid coral, apparently exposing one of the tabulae and a trace of the fossula at its base. Its surface is marked by transverse lines of growth. The specimen should be sectioned to determine the structure of its interior, by this means establishing its actual relationship.

Locality and Horizon.—Limestone rapids of the Severn river; either in the Ekwan or Attawapiskat limestone. No. 341S in the Royal Ontario Museum of Paleontology.

B. **Euomphalus cf. rotundus Parks**

Plate VII, figs. 7 A, B, C

Barrandeoceras sp. indet., Parks, Trans. Royal Canadian Inst., 11, 1915, p. 79, pl. 7, fig. 8; pl. 5, fig. 11.
Cf. *Euomphalus rotundus* Parks, idem. pl. 7, figs. 6, 7.

Part of a volution in which the transverse striae on the surface of the shell follow the oblique course characteristic of *Euomphalus;* slightly convex in an orad direction along the upper side of the volution, slightly concave in an orad direction along its lower side, and obliquely upward and orad laterally, where passing from the lower to the upper side of the volution.

Locality and Horizon.—Limestone rapids on the Severn river; either in the Ekwan or Attawapiskat limestone. No. 342S in the Royal Ontario Museum of Paleontology.

Remarks.—This specimen came from the same locality and horizon as the type of *Euomphalus rotundus* Parks, to which it appears closely related.

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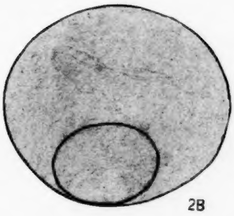
PLATE I

Fig. 1. *Endoceras nelsonense* Foerste and Savage. Lateral view, with siphuncle projecting at base. Nelson river; at horizon 3, in the Nelson limestone. No. 1 HB in the Savage collection. Reduced to 0.84 of original diameter.

Fig. 2. *Endoceras* (?) *sp*. A, lateral view; B, cross-section at its base, showing siphuncle. Southern end of west shore of North Arm of Great Slave Lake; in the Ordovician. Collected by Dr. George S. Hume. Reduced to 0.84 of original diameter.

1

2A



2B

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PLATE II

Fig. 1. *Endoceras fulgur* (Billings). Lateral view. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 2 HB in the Savage collection.

Fig. 2. *Cameroceras vanluyli* Foerste and Savage. Siphuncle with endocone projecting at base; ventral side on left. Severn river; at horizon 10 in the Attawapiskat limestone. No. 3 HB in the Savage collection.

Fig. 3. *Ormoceras* (?) *sp.* Weathered specimen showing traces of the siphuncle. Arctic America; presumably from the Silurian. Collected by Capt. H. W. Fielden in the expedition of the "Alert" and "Discovery," in 1875-76, No. 89175 in the British Museum of Natural History.

Fig. 4. *Endoceras* (?) *hudsonicum* Parks. Vertical section through the siphuncle, showing septal necks displaced by distortion. Limestone rapids on the Severn river; either from the Ekwan or Attawapiskat limestone. Holotype. No. 3228 in the Royal Ontario Museum of Paleontology.

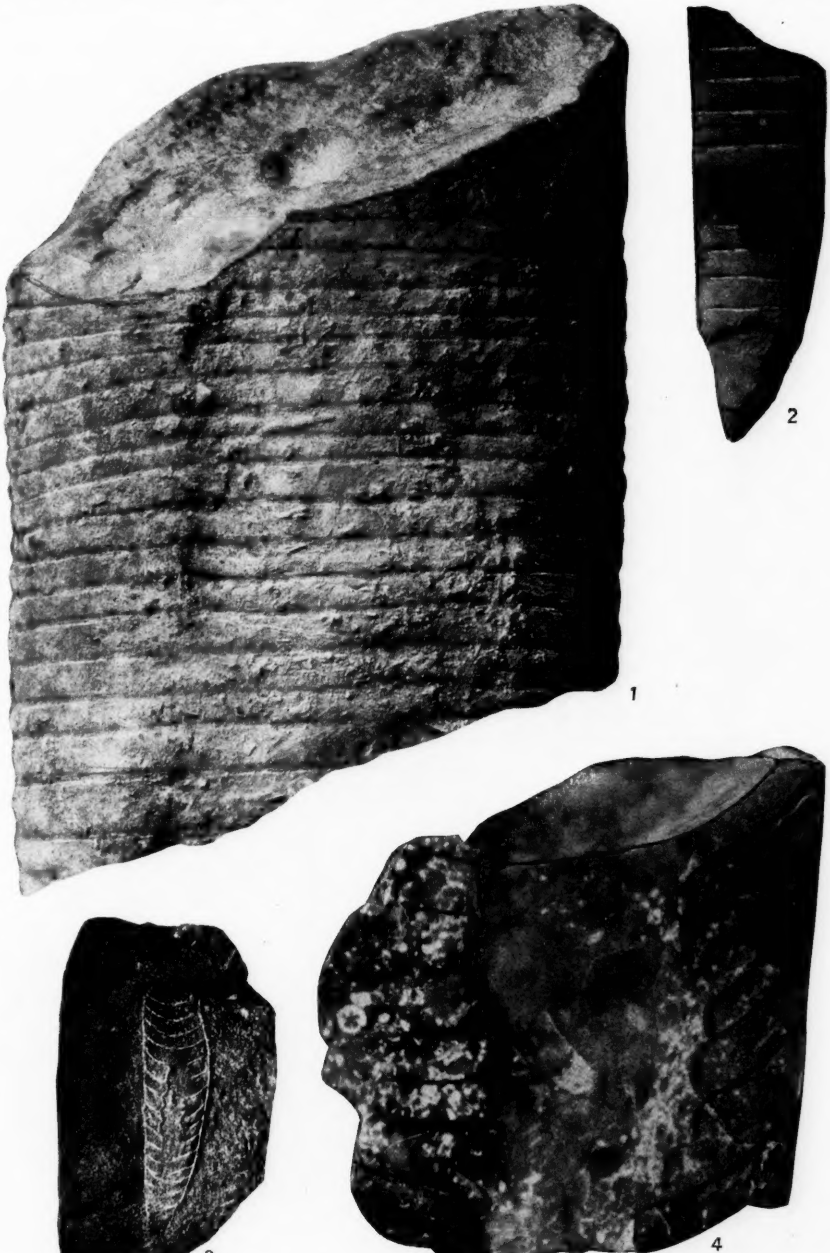

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PLATE III

Fig. 1. *Shamattawaceras ascoceroides* Foerste and Savage. A, dorsal view; B. lateral view; C, ventral view. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 7 HB in the Savage collection.

Fig. 2. *Billingsites boreale* (Parks). Lateral view, with ventral side on right. Specimen depressed dorso-ventrally, as in type of species. Shamattawa river; at horizon 1, in Shamattawa limestone. No. 5 HB in the Savage collection.

Fig. 3. *Billingsites boreale* (Parks). Lateral view, with ventral side on right. Specimen only slightly depressed dorso-ventrally, nearly circular in cross-section. B, same specimen, basal view, with ventral side along the lower margin, showing course of compound suture of lower septa and location of the siphuncle. Same locality and horizon as the preceding. No. 6 HB in the Savage collection.

Fig. 4. *Billingsites boreale* (Parks). A, ventral view; B, dorsal view; C, lateral view, with ventral side on right; D, dorso-ventral vertical section, showing siphuncle at base. Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 326S in the Royal Ontario Museum of Paleontology.

Fig. 5. *Armenoceras sphaeroidale* (Stokes). Vertical section showing segments of the siphuncle. Collected by the expedition of the "Alert" and the "Discovery" during the years 1875–76, from some unknown locality, possibly Dobbin Bay; in the Niagaran division of the Silurian. No. C2712 in the British Museum of Natural History.

Fig. 6. *Armenoceras donetti* Foerste. Cast of interior of phragmacone and impression of part of exterior at its base. Cornwallis Island; Silurian. Collected in 1851 by Dr. P. C. Sutherland. No. 96966 in the British Museum of Natural History.

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PLATE IV

Fig. 1. *Ephippiorthoceras ekwanense* (Whiteaves). A, lateral view, lower part of phragmacone sectioned dorso-ventrally in order to show the siphuncle, but only the septal necks are preserved; B, dorsal or ventral side, the siphuncle being central in location. Portage road at falls of the Ekwan river; presumably in the Attawapiskat limestone. No. 4414 in the collections of the Geological Survey of Canada.

Fig. 2. *Kionoceras septentrionale* Foerste and Savage. Lateral view, magnified 2 diameters. Ekwan river; at horizon 2, in the Ekwan limestone. No. 16 HB in the Savage collection.

Fig. 3. *Ephippiorthoceras dowlingi* Foerste and Savage. A, dorsal view; B, lateral view, with ventral side on left, sectioned dorso-ventrally at lower camera to show the siphuncle. Shamattawa river; at horizon 2, in the Shamattawa limestone. No. 19 HB in the Savage collection.

Fig. 4. *Geisonoceras* (?) *sp.* Lateral view, showing transverse striae on surface of shell. Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 333S-b in the Royal Ontario Museum of Paleontology.

Fig. 5. *Cycloceras* (?) *sp.* Lateral view with ventral side on left. Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 332S in the Royal Ontario Museum of Paleontology.

Fig. 6. *Armenoceras cf. ommaneyi* (Salter). Ventral side of conch viewed from above, showing size of siphuncle at septal neck. From Assistance Bay, on the southeast coast of Cornwallis Island. Collected by Dr. P. C. Sutherland, in strata regarded as Silurian. No. 96954 in the British Museum of Natural History.

Fig. 7. *Protokionoceras submedullare* Foerste and Savage. Lateral view showing vertical riblets which are more conspicuous than the lateral striae. Severn river; at horizon 10, in the Attawapiskat limestone. No. 17 HB in the Savage collection.

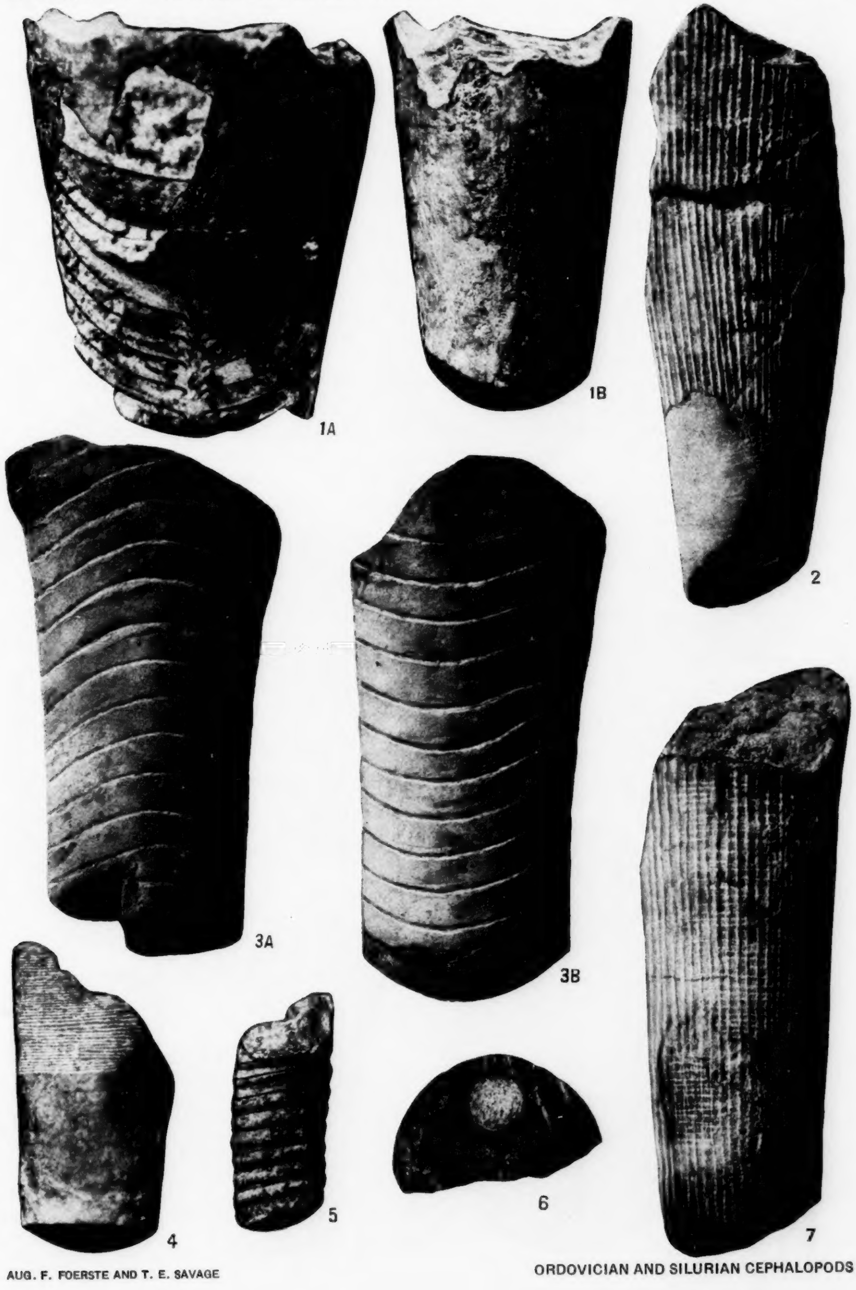

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PLATE V

Fig. 1. *Spyroceras boreale* Foerste and Savage. Lateral view, enlarged 1.85 diameters. Ekwan river; at horizon 2, in the Ekwan limestone. No. 14 HB in the Savage collection.

Figs. 2, 3. *Spyroceras geronticum* Foerste and Savage. A, lateral view of straight conch; B, lateral view of moderately curved conch; curvature possibly due to distortion. Shamattawa river; at horizon 2, in the Shamattawa limestone. Nos. 12 HB and 13 HB in the Savage collection.

Fig. 4. *Cycloceras sinuoliratum* Foerste and Savage. Lateral view; enlarged 2 diameters. Severn river; at horizon 10, in the Attawapiskat limestone. No. 10 HB in the Savage collection.

Fig. 5. *Kionoceras sp.* Lateral view of living chamber with 2 camerae still attached; chamber constricted at mid-height. Severn river; at horizon 8, in the Ekwan limestone. No. 15 HB in the Savage collection.

Fig. 6. *Cyrtorizoceras sp.* A, ventral view; B, lateral view, with ventral side on right. Limestone rapids on the Severn river; in either the Ekwan or Attawapiskat limestone. No. 336S-b in the Royal Ontario Museum of Paleontology.

Fig. 7. *Rizoceras* (?) *coronatum* Foerste and Savage. Ventral view, showing scalloped transverse striae on surface of shell. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 22 HB in the Savage collection.

Fig. 8. *Westonoceras* (?) *septentrionale* Foerste and Savage. Lateral view, with ventral side on left. Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 27 HB in the Savage collection.

Fig. 9. *Protophragmoceras* (?) *sp.* Lateral view, with ventral side on right; enlarged 2 diameters. Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 45 HB in the Savage collection.

Fig. 10. *Cycloceras acutoliratum* Foerste and Savage. Lateral view. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 8 HB in the Savage collection.

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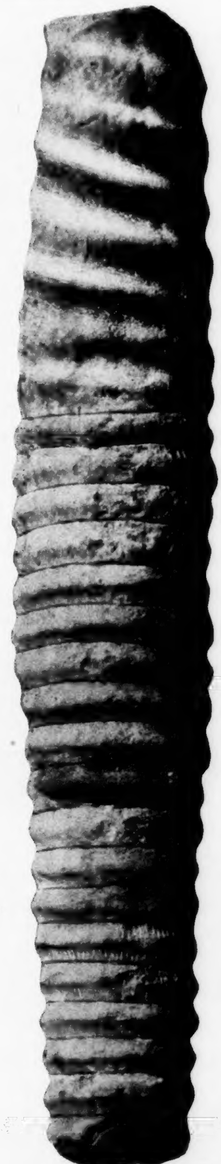
PLATE VI

Fig. 1. *Spyroceras geronticum* Foerste and Savage. A, dorsal view; B, lateral view with ventral side on right. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 77 HB in the Savage collection.

Fig. 2. *Stokesoceras ekwanense* Foerste and Savage. Dorsal view. Ekwan river; at horizon 2, in the Ekwan limestone. No. 36 HB in the Savage collection.

Fig. 3. *Cycloceras acutoliratum* Foerste and Savage. Lateral view, with ventral side on left. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 9 HB in the Savage collection.

1A



1B

2

3

PLATE VII

Fig. 1. *Kochoceras lenticulare* Foerste. Ventral side, showing contact areas between connecting rings of siphuncle and ventral wall of conch. Collected on expedition of the "Alert" and the "Discovery" during the years 1875–76, from some unknown locality, probably between Dobbin bay and Scoreby Bay, on the east coast of Ellesmereland. No. C2712-a in the British Museum of Natural History.

Fig. 2. *Kochoceras shamattawaense* Foerste and Savage. Dorso-ventral vertical section through the siphuncle, showing traces of connecting rings. Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 315S in the Royal Ontario Museum of Paleontology.

Fig. 3. *Kochoceras mantelli* Foerste. Ventral side of conch showing contact areas between connecting rings and ventral wall of conch. From Igloolik Island, in Fox channel, in Arctic America; in Ordovician strata. Collected by Dr. G. A. Mantell in 1839. No. 33563 in the British Museum of Natural History.

Fig. 4. *Orthoceras* (?) *slavense* Foerste and Savage. A, ventral view; B, transverse section at septum, showing siphuncle at septal neck. From southern part of west shore of North Arm of Great Slave Lake; in cherty rock from Ordovician. Collected by Dr. George S. Hume. Magnified 2 diameters.

Fig. 5. *Plectoceras* (?) *sp*. A, lateral view of specimen, its convex outline being ventral; showing sutures of septa at smaller end, and transverse striae on surface of shell farther up; B, cross-section at septum, showing siphuncle; C, ventral view, oriented sidewise, showing downward curvature of striae due to former locations of hyponomic sinus; also ventral location of siphuncle on curved septum at base of fragment. From southern part of west shore of North Arm of Great Slave Lake; in the Ordovician. Collected by Dr. George S. Hume. Magnified 3 and 3.5 diameters.

Fig. 6. *Stokesoceras ekwanense* Foerste and Savage. Lateral view, with ventral side on left. Ekwan river; at horizon 2, in the Ekwan limestone. No. 37 HB in the Savage collection. See also fig. 2 on pl. VI, and fig. 6 on pl. XI.

Fig. 7. *Euomphalus cf. rotundus* Parks. A, upper side of volution; B, lower side; C, exterior lateral side. Limestone rapids on Severn river; either in the Ekwan or Attawapiskat limestone. Specimen No. 342S in the Royal Ontario Museum of Paleontology.


1
2
3
4B
X2
X2
4A
X3
5A
X3.5
5B
X3.5
5C
6
7A
7B
7C

PLATE VIII

Fig. 1. *Armenoceras magnum* (Parks). Vertical section through the siphuncle. Mouth of Shamattawa river; in the Shamattawa limestone. No. 309S in the Royal Ontario Museum of Paleontology.

Fig. 2. *Huroniella subinflecta* Foerste and Savage. Lateral view of siphuncle. Severn river; at horizon 10, in the Attawapiskat limestone. No. 32 HB in the Savage collection.

Fig. 3. *Discosorus parksi* Foerste and Savage. Lateral view. Assina rapids on the Severn river; from the Ekwan limestone. No. 313S in the Royal Ontario Museum of Paleontology. See fig. 8 on pl. XXIII for other view of same specimen; also figs. 3 A, B, C, on pl. XII.

Fig. 4. *Armenoceras hearsti* (Parks). Lateral view of broken specimen, with ventral side on right, showing siphuncle and part of some of the septa. Limestone rapids of the Severn river; either from the Ekwan or Attawapiskat limestone. Holotype. No. 314S in the Royal Ontario Museum of Paleontology. See also pl. XXIV, fig. 5.

PLATE VIII

1

2

3

4

PLATE IX

Figs. 1, 2, 3. *Armenoceras lowi* Foerste and Savage. 1, 2, lateral views; 3, vertical section through another specimen. Southern half of west coast of Southampton Island; in the Silurian. Nos. 7905-a, b, d, in the collections of the Geological Survey of Canada.

Fig. 4. *Armenoceras inclinatum* Foerste and Savage. Lateral view of siphuncle. Southern half of west coast of Southampton Island; in the Silurian. No. 7905-i in the collections of the Geological Survey of Canada.

Figs. 5, 6. *Armenoceras southamptonense* Foerste and Savage. 5, lateral view, with ventral side on right; 6, vertical section through siphuncle in a dorso-ventral direction. Southern half of west coast of Southampton Island; in the Silurian. Nos. 7905-k, j, in the collections of the Geological Survey of Canada.

Fig. 7. *Armenoceras sp.* A, lateral view of siphuncle, retaining a fragment of the ventral side of the conch along its lower left margin; B, vertical section in a lateral direction through the upper 6 segments. From the drift at York factory, at the mouth of Nelson river; horizon unknown. No. 311S in the Royal Ontario Museum of Paleontology.

Fig. 8. *Orthoceras cf. griffithi* Haughton. View of septum at base, showing passage of siphuncle. See also fig. 2 on plate X. No. C2126 in the collections of the British Museum of Natural History.

Fig. 9. *Tyrrelloceras striatum* Foerste and Savage. Lateral view, with ventral side on left. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 28 HB in the Savage collection.

Fig. 10. *Tripteroceras shamattawaense* Foerste and Savage. Dorsal view. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 20 HB in the Savage collection.

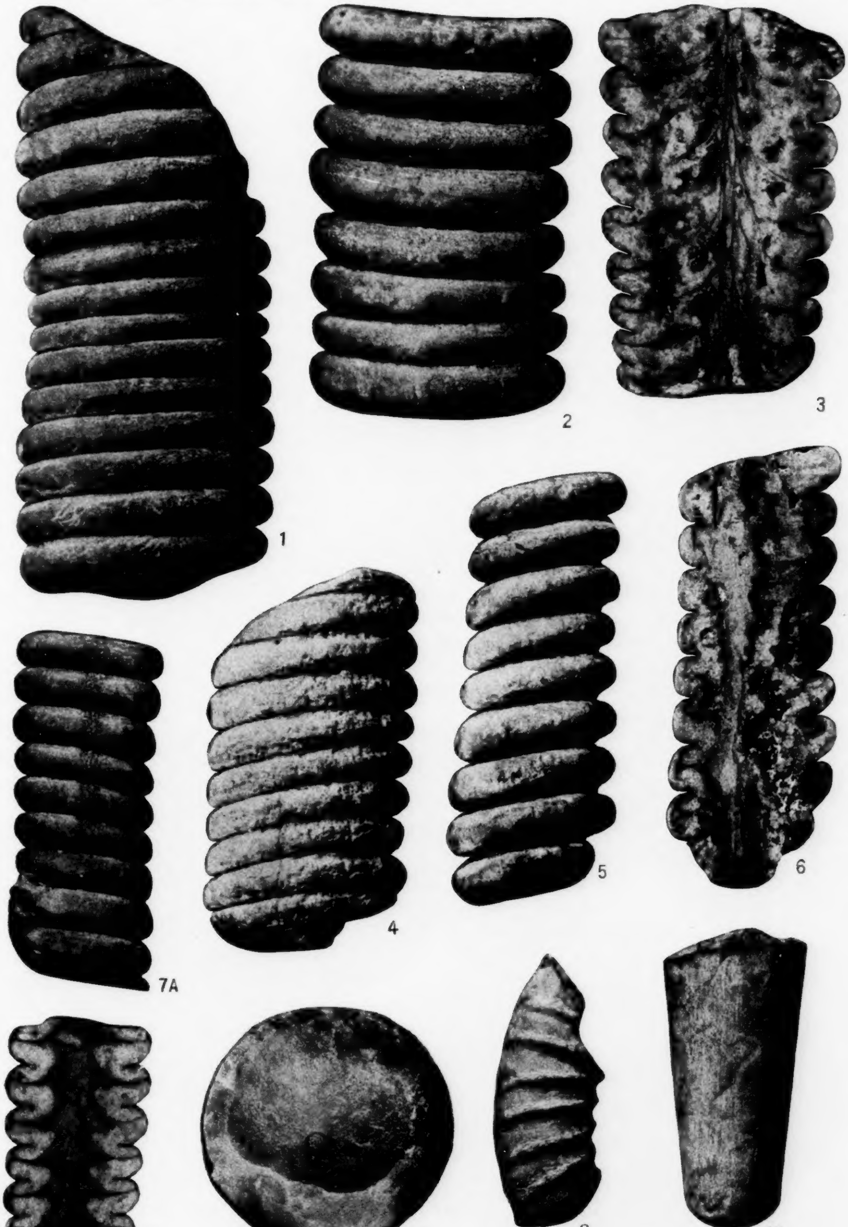


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PLATE X

Fig. 1. *Kochoceras fieldeni* Foerste. A, ventral view, with segment of siphuncle at its base; B, dorsal view; C, basal view, showing outline of segment of siphuncle. Cape Louis Napoleon, west of Kane Basin, Arctic America. Collected by Capt. H. W. Fielden. No. 89179 in British Museum of Natural History.

Fig. 2. *Orthoceras griffithi* Houghton. Lateral view. Griffith Island, south of Cornwallis Island; presumably in the Silurian. No. C2126a in the British Museum of Natural History. See also fig. 8 on plate IX.

PLATE X

1A

2

1B

1C

PLATE XI

Fig. 1. *Huroniella inflecta* (Parks). A,lateral view, with ventral side on right; B, dorso-ventral cross-section of same, showing adnation of septa to lower side of segments, the ventral side being on the left. Limestone rapids on the Severn river; presumably in the Ekwan limestone. No. 310S in the Royal Ontario Museum of Paleontology. Holotype.

Fig. 2. *Discosorus troedssoni* Foerste and Savage. A, ventral view of siphuncle; B, lateral view of same, with ventral side on right. Southern half of west coast of Southampton Island; in the Silurian. Collected by A. P. Low. No. 7906 in the collections of the Geological Survey of Canada.

Fig. 3. *Huroniella inflecta* (Parks). Ventral view. From 8 miles above the entrance of the Pagwachuan river into the Kenogami; in the Silurian. Collected by M. Y. Williams.

Fig. 4. *Armenoceras severnense* Foerste and Savage. A, ventral side, showing trace of contact areas between the upper part of the segments of the siphuncle and the ventral wall of the conch; B, lateral view, with ventral side on left, the dorsal side of the siphuncle being weathered away. The lower part of the ventral side of the siphuncle exposes the vertical radiating plates, which are better exposed at the top and bottom of the specimen. Severn river; at horizon 10, in the Attawapiskat limestone. No. 31 HB in the Savage collection.

Fig. 5. *Armenoceras cf. richardsoni* (Stokes). Ventral view of siphuncle. Shamattawa river; at horizon 1 or 2, in the Shamattawa limestone. No. 30 HB in the Savage collection.

Fig. 6. *Stokesoceras ekwanense* Foerste and Savage. Dorsal side of siphuncle. Severn river; in horizon 6, in the Ekwan limestone. No. 38 HB in the Savage collection. See also fig. 2 on pl. VI, and fig. 6 on pl. VII.

PLATE XI

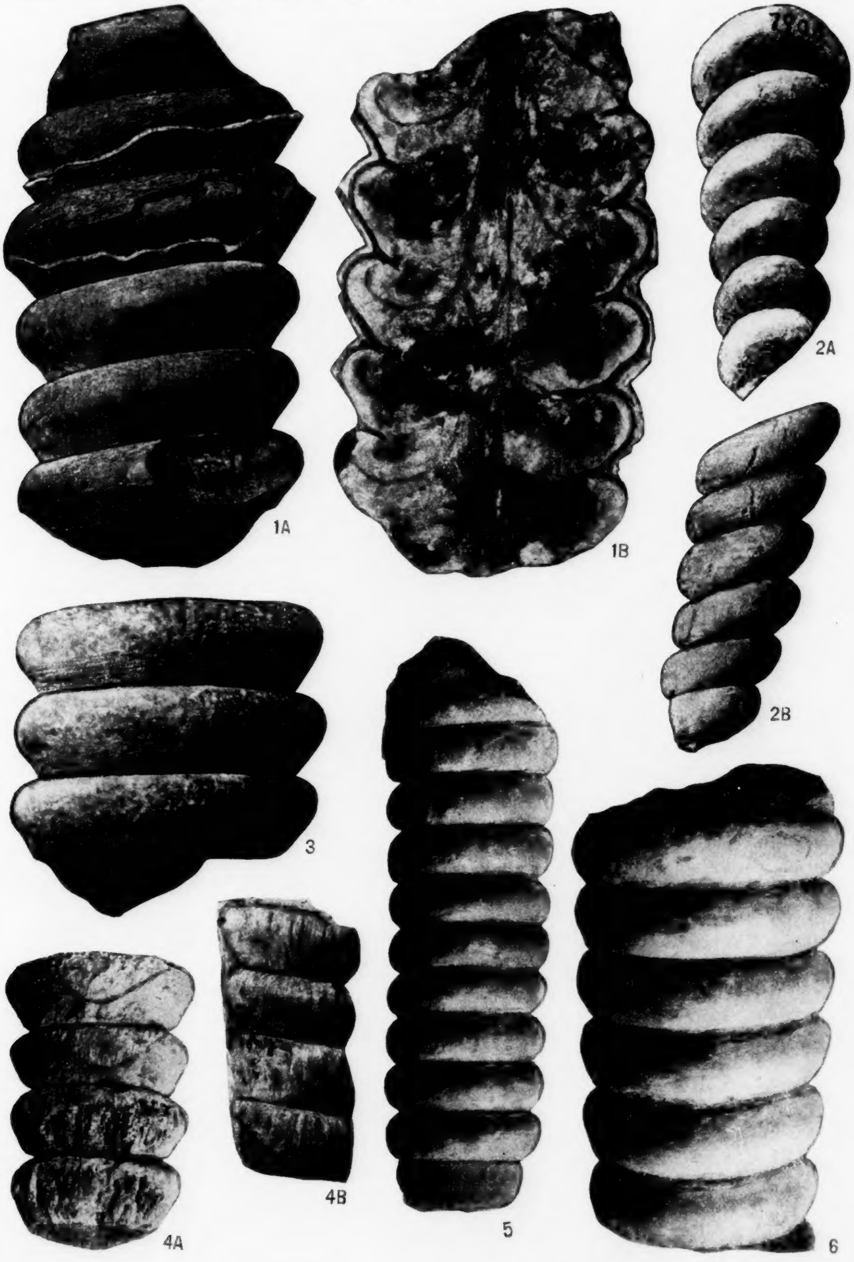

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PLATE XII

Fig. 1. *Huronia septata* Parks. Lateral view showing septa adnate to lower and narrower half of segments of siphuncle. Shamattawa river; at horizon 2, in the Shamattawa limestone. No. 33 HB in the Savage collection.

Fig. 2. *Huronia septata* Parks. Vertical section through center of siphuncle; lower 3 segments in their natural condition due to weathering, upper 3 segments ground flat. From the lower rapids on the Shamattawa river; in the Shamattawa limestone. No. 312S in the Royal Ontario Museum of Paleontology; Holotype.

Fig. 3. *Discosorus parksi* Foerste and Savage. A, three segments of siphuncle viewed from beneath; showing excentric location of septal neck, also contact areas with ventral wall of conch along the upper parts of two of the segments as oriented in the figure; B, same, viewed from above, showing annular concave zone immediately exterior to septal necks; C, lateral view of same, with ventral contact areas on left. Ekwan river; at horizon 2, in Ekwan limestone. No. 39 HB in the Savage collection. Holotype.

Fig. 4. *Huronia cf. septata* Parks. Lateral view, of a weathered specimen. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 34 HB in the Savage collection.

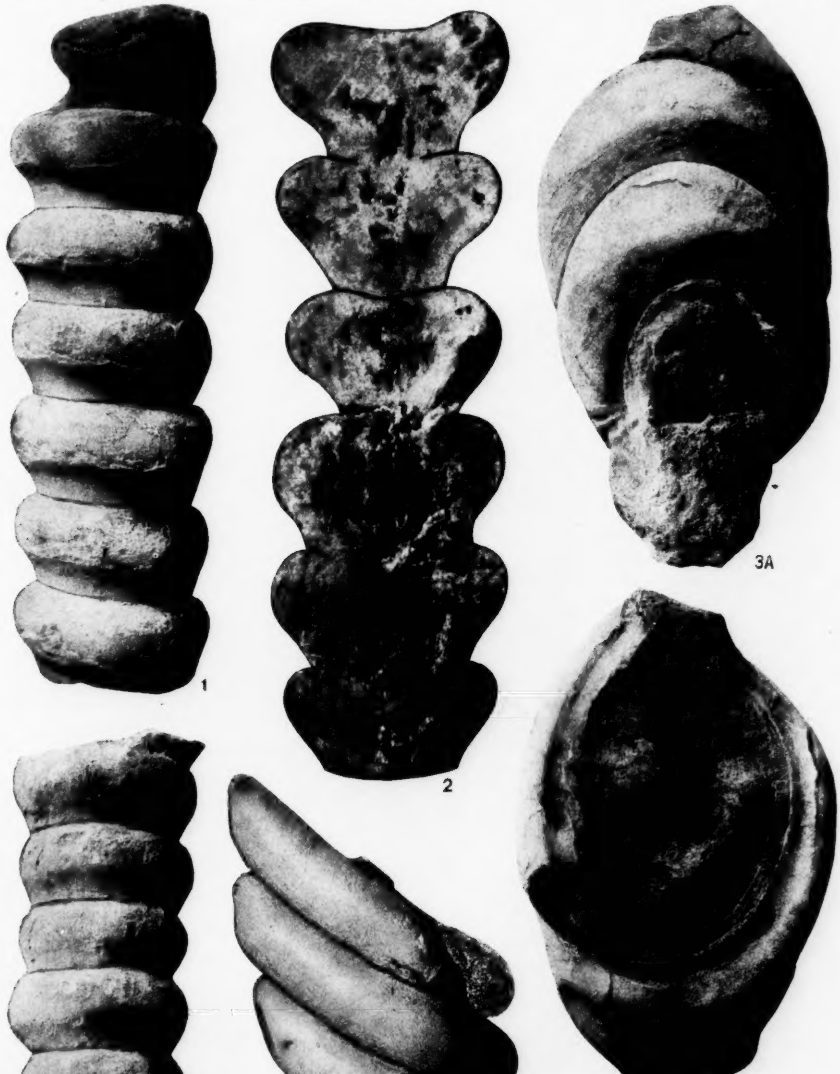

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PLATE XIII

Fig. 1. *Tuyloceras percurvatum* Foerste and Savage. A, lateral view, exposing siphuncle; B, ventral view, slightly oblique, showing siphuncle. Ekwan river; at horizon 2, in the Ekwan limestone. No. 40 HB in the Savage collection.

Fig.2. *Lowoceras southamptonense* Foerste and Savage. A, ventral view of siphuncle; B, dorsal view; C, lateral view with ventral side on right. Southern half of west side of Southampton Island; in the Silurian. No. 7906-a in the collections of the Geological Survey of Canada.

Fig. 3. *Armenoceras sp.* A, lateral view, with ventral side on left; B, dorsal view. Southern half of west coast of Southampton Island; in the Silurian. No. 7906-a in the collections of the Geological Survey of Canada.

Fig. 4. *Stokesoceras cf. perobliquum* Foerste. A, lateral view of siphuncle, with ventral side on right; B, ventral side tilted so as to show overlapping of successive segments. Southern half of west coast of Southampton Island; in the Silurian. No. 7847 in the collections of the Geological Survey of Canada.


1A
2A
1B
2B
3A
3B
2C
4A
4B

PLATE XIV

Fig. 1. *Apsidoceras boreale* Foerste and Savage. A, dorsal view; B, lateral view, with ventral side on left; C, ventral side, restored along upper left side of figure. Shamattawa river; at horizon 2, in the Shamattawa limestone. No. 29 HB in the Savage collection.

Fig. 2. *Oocerina severnense* Foerste and Savage. A, B, opposite views of dorso-ventral section through siphuncle of same specimen; C, exterior of same. Limestone rapids of the Severn river; either in the Ekwan or Attawapiskat limestone. No. 330S-a in the Royal Ontario Museum of Paleontology.

Fig. 3. *Tyrrelloceras* (?) *striatum* Foerste and Savage. Ventral view, showing transverse ribs, and also transverse and longitudinal striae. Along the ventral side some of the longitudinal striae are distinctly broader and more conspicuous than others. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 28 HB in the Savage collection. Figure enlarged 2.2 diameters.

Fig. 4. *Oocerina sp.* Living chamber, and part of phragmacone, weathered so as to expose interior, and ground down so as to expose siphuncle. Limestone rapids on the Severn river; either from the Ekwan or Attawapiskat limestone. No. 330S-b in the Royal Ontario Museum of Paleontology.

Fig. 5. *Protophragmoceras* (?) *boreale* Foerste and Savage. Lateral view with siphuncle on right side; showing sutures of septa and also the transverse striae on the surface of the shell. Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 44 HB in the Savage collection. Holotype.

Fig. 6. *Protophragmoceras* (?) *boreale* Foerste and Savage. Lateral view with ventral side on left; showing transverse striae on surface of shell. Falls of Ekwan river; presumably from the Attawapiskat limestone. No. 4405 in the collection of the Geological Survey of Canada.

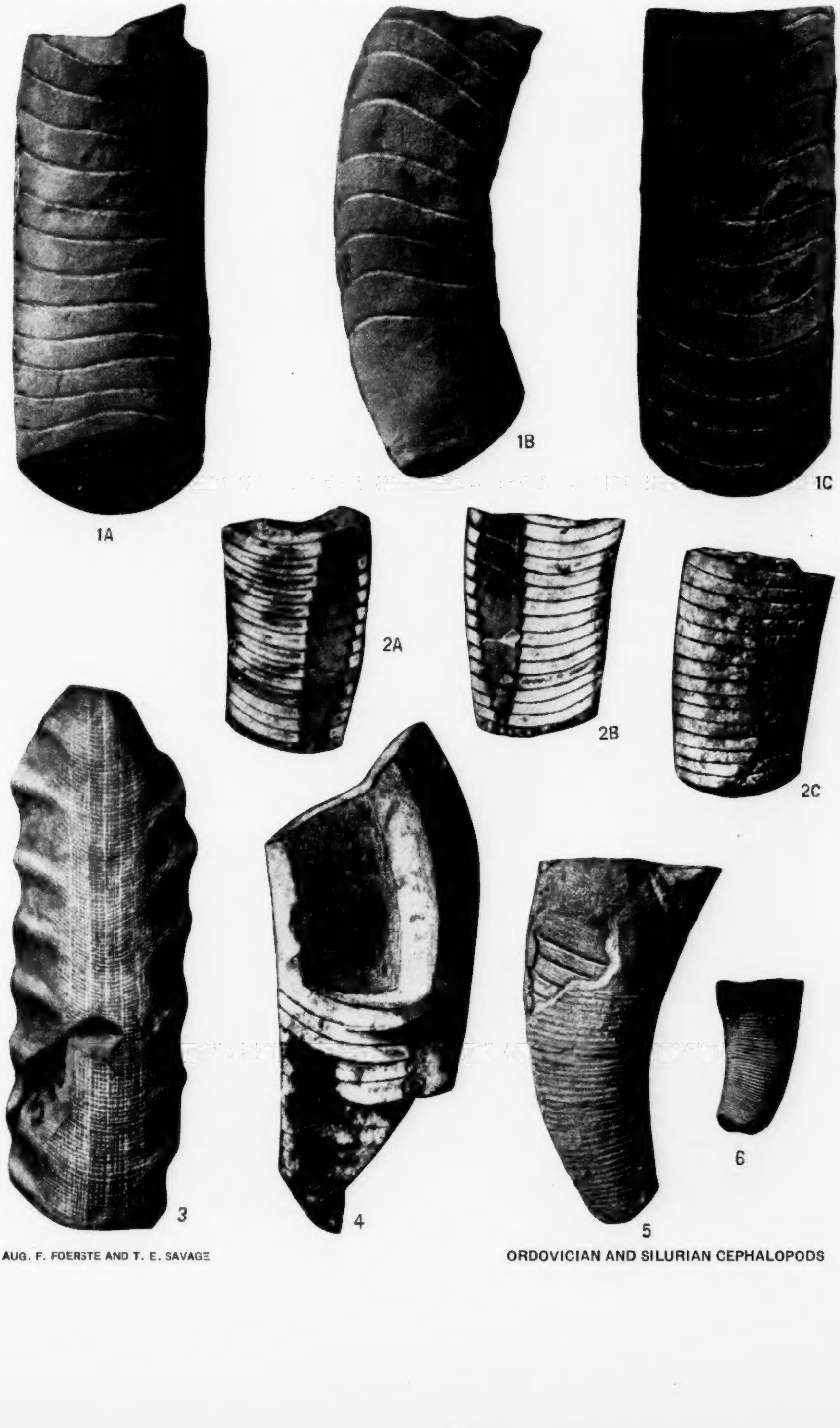

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PLATE XV

Fig. 1. *Dunleithoceras cordatum* (Parks). A, ventral side; B, lateral view, with ventral side on left; C, dorsal side; D, transverse section at one of the septa, with ventral side at top of figure, showing location of siphuncle. From drift at Nelson river; presumably from Ordovician strata. No.329S in the Royal Ontario Museum of Paleontology.

Fig. 2. *Oocerina shamattawaense* Foerste and Savage. A, weathered lateral side, exposing siphuncle; B, opposite lateral view, with ventral side on right. Lower rapids of Shamattawa river; in the Shamattawa limestone. No. 333S-a in the Royal Ontario Museum of Paleontology.

Fig. 3. *Oocerina* (?) *sp.* A, lateral view; B, dorso-ventral cross-section of the same with trace of dorsal outline of the siphuncle apparently. Lower rapids of Shamattawa river; in the Shamattawa limestone. No. 328S in the Royal Ontario Museum of Paleontology.

Fig. 4. *Diestoceras sp.* A, diagonally compressed specimen, viewed from beneath; siphuncle apparently exposed at top of basal septum as oriented in the figure; B, apparently the ventral view, much distorted by oblique pressure, one of the lateral sides in consequence having a concave vertical outline. Nelson river; at horizon 3, in the Nelson limestone. No. 41 HB in the Savage collection.


1A
1B
1C
1D
2A
2B
3A
3B
4A
4B

PLATE XVI

Fig. 1. *Diestoceras tyrrelli* (Parks). A, ventral view; B, lateral view, with ventral side on left; C, top of phragmacone, viewed from above, with siphuncle along upper part of figure. Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 320S in the Royal Ontario Museum of Paleontology.

Fig. 2. *Westenoceras* (?) *contractum* Foerste and Savage. A, lateral view with ventral side on right; B, ventral view; specimen restored near aperture. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 26 HB in the Savage collection.

Fig. 3. *Phragmoceras sp.* A, lateral view, with ventral side on right; B, dorsal view, restored along left. Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 51 HB in the Savage collection.

Fig. 4. *Armenoceras* sp., near *Huroniella*. A, dorso-ventral section through a siphuncle, with ventral side on left; B, diagonal ventral view, with typical ventral outline on left side of segments. Bessell's Bay, at northern end of Kennedy channel, directly west of Peterman Fiord; collected in 1875 by Capt. H. W. Fielden. No. C2713 in the British Museum of Natural History.

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PLATE XVII

Fig. 1. *Phragmoceras* (?) *cameroni* Foerste and Savage. A, lateral view, with the ventral side on the left; B, viewed from above, showing outline of aperture in its present condition. Great Slave Lake, at southern end of west side of North Arm; in Silurian strata approximately corresponding to the Attawapiskat limestone. Collected by Dr. George S. Hume.

Fig. 2. *Cyrtogomphoceras nutatum* Foerste and Savage. A, lateral view with ventral side on left; B, ventral view; both views apparently showing trace of hyponomic sinus. Nelson river; at horizon 4, in the Nelson limestone. No. 42 HB in the Savage collection.

Fig. 3. *Byronoceras* (?) *humei* Foerste and Savage. A, lateral view of living chamber, with trace of siphuncle at base; B, cross-section at base of chamber. Great Slave Lake; at southern end of west shore of North Arm; in the Silurian. Collected by Dr. George S. Hume.

Fig. 4. *Crateroceras* (?) *humei* Foerste and Savage. A, lateral view of living chamber, with trace of siphuncle at base. Great Slave Lake, at southern end of west shore of North Arm; in the Silurian. Collected by Dr. George S. Hume.

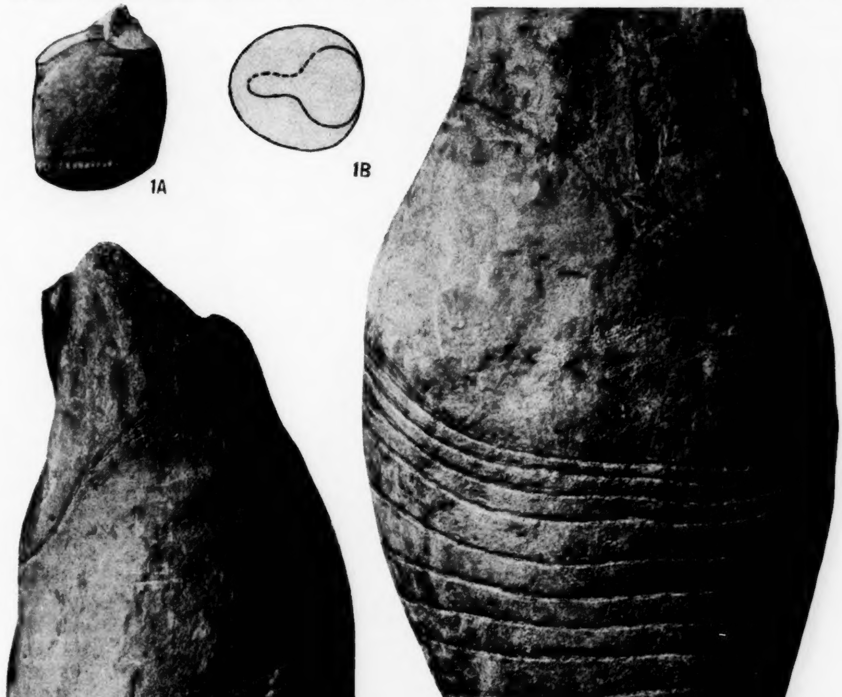
1A
1B
2A
2B
3A
3B
4A
4B

PLATE XVIII

Fig. 1. *Westenoceras sp.* (Nelson river) A, lateral view, with ventral side on left; B, dorsal side. Nelson river; at horizon 4, in the Nelson limestone. No. 25 HB in the Savage collection.

Fig. 2. *Chicagooceras* (?) *longidomum* Foerste and Savage. A, dorsal side; B, lateral view showing living chamber, with vertical section through the phragmacone exposing siphuncle; ventral side on left. Specimen A from Ekwan river; at horizon 7, in the Attawapiskat limestone; No. 21 HB in the Savage collection. Specimen B from the limestone rapids of the Severn river; in either the Attawapiskat or Ekwan limestone; No. 335S in the Royal Ontario Museum of Paleontology.

Fig. 3. *Parksoceras lepidodendroides* (Parks). A, lateral view of one of the flattened sides; B, lateral view of one of the compressed sides, with vertically elongate elevations. Lower rapids of the Shamattawa river; in the Shamattawa limestone. No. 321S in the Royal Ontario Museum of Paleontology.

Fig. 4. *Stokesoceras cylindratum* Foerste and Savage. Lateral view. Ekwan view; at horizon 4, in the Ekwan limestone. No. 35 HB in the Savage collection.

PLATE XVIII

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PLATE XIX

Fig. 1. *Cyrtogomphoceras* (?) *shamattawaense* Foerste and Savage. A, ventral view, with a faint trace of the hyponomic sinus; B, lateral view with ventral side on left. Shamattawa river; at horizon 1, in the Shamattawa limestone. No. 43 HB in the Savage collection.

Fig. 2. *Phragmoceras severnense* Foerste and Savage. A, lateral view; B, same, viewed from above, showing the aperture. Severn river; at horizon 2, in the Severn limestone. No. 48 HB in the Savage collection.

Figs. 3–6. *Phragmoceras nelsonense* Parks. 3, type, lateral view; 4, lateral view of another specimen; 5 A, B, two views of a living chamber; 6, lateral view of a second living chamber. From drift at entry of Seal river into the Nelson river; from the Silurian, probably in the Ekwan limestone. Nos. 316S a, b, c, d, in the Royal Ontario Museum of Paleontology. Figures 3, 4, 5 correspond to fig. 7 on pl. 1, and figs 1, 2, on pl. 3, accompanying the original description by Parks. The original of fig. 6 has not been illustrated heretofore.

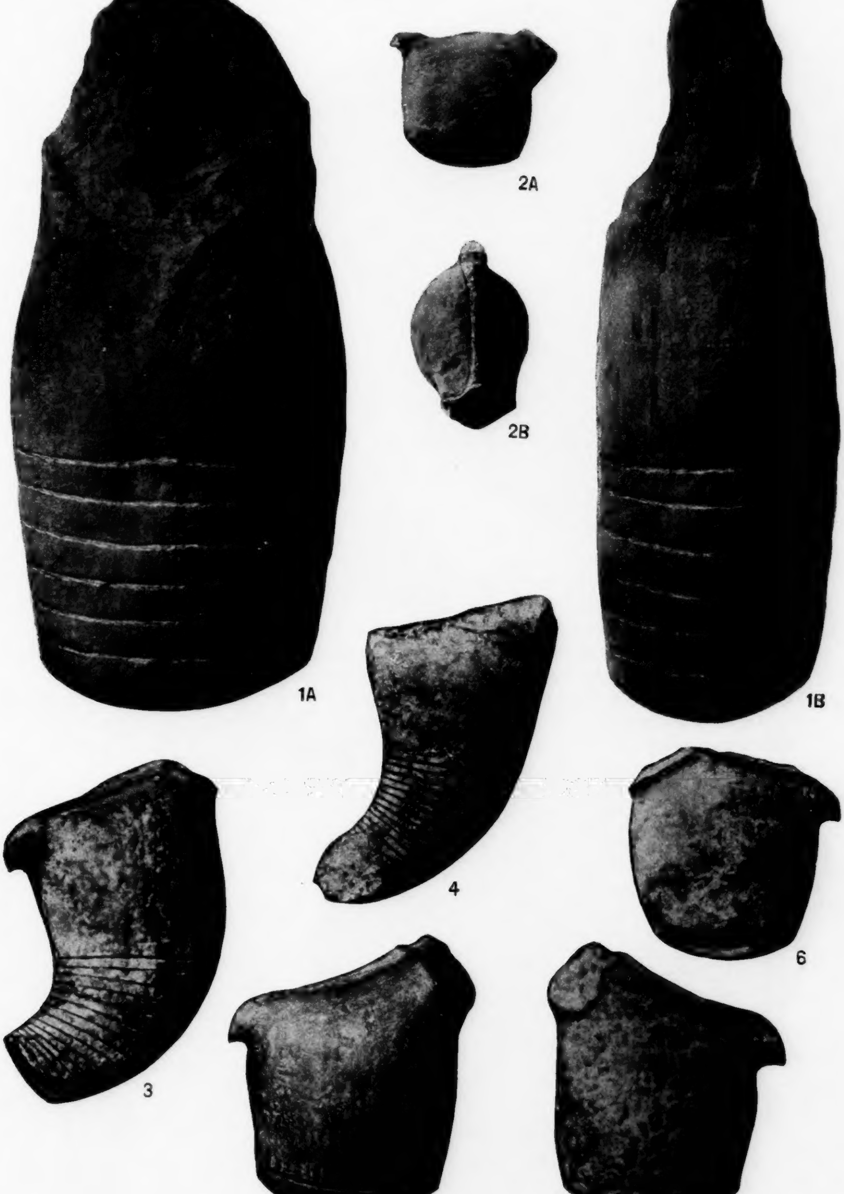

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PLATE XX

Fig. 1. *Phragmoceras lineolatum* Whiteaves. Top of living chamber, showing abrupt junction of narrowly linear part of aperture with dorsal lobe of same; ventral end of aperture restored in figure. Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 50 HB in the Savage collection.

Fig. 2. *Phragmoceras whiteavesi* Foerste and Savage. Lateral view, with projecting lip at hyponomic sinus restored. Middle rapid of the Falls of the Ekwan river; presumably in the Attawapiskat limestone. No. 4405a in the collections of the Geological Survey of Canada.

Fig. 3. *Phragmoceras lineolatum* Whiteaves. A, Lateral view, restored at dorsal end of aperture; B, aperture of same, restored at dorsal end. Falls of Ekwan river; probably from the Attawapiskat limestone. Type. No. 4404 in the collections of the Geological Survey of Canada.

Fig. 4. *Phragmoceras sp.* (Severn river). Lateral view. Limestone rapids on the Severn river; in either the Ekwan or Attawapiskat limestone. No. 317S in the Royal Ontario Museum of Paleontology.

1

2

3A

3B

4

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PLATE XXI

Fig. 1. *Phragmoceras parksi* Foerste and Savage. A, lateral view; B, ventral view. Severn river; at horizon 10, in the Attawapiskat limestone. No. 49 HB in the Savage collection.

Fig. 2. *Phragmoceras vantuyli* Foerste and Savage. A, lateral view, with dorsal side on right; B, viewed from above, showing narrowly linear part of aperture and trace of dorsal lobe at lower end of figure. Ekwan river; at horizon 7, in the Attawapiskat limestone. No. 52 HB in the Savage collection.

1A

1B

2A

2B

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PLATE XXII

Fig. 1. *Phragmoceras whitneyi* Parks. Lateral view; outline of dorsal lobe of aperture uncertain. Limestone rapids on the Severn river; in the Silurian, presumably in the Ekwan limestone. Type. No. 3188 in the Royal Ontario Museum of Paleontology. Size, 0.86 diameter.

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PLATE XXIII

Figs. 1, 2. *Ekwanoceras breviconicum* Foerste and Savage. 1A, lateral view; 1B, dorsal view; 2, ventral view of another specimen, the holotype. Ekwan river; at horizon 7, in the Attawapiskat limestone. Nos. 24 HB and 23 HB in the Savage collection.

Figs. 3, 4. *Protophragmoceras* (?) *sp.* 3A, lateral view of living chamber, with ventral side on left; 3B, dorsal side; 4 A, B, corresponding sides of another specimen. Both specimens restored along aperture. Ekwan river; at horizon 7, in the Attawapiskat limestone. Nos. 46 HB and 47 HB in the Savage collection.

Fig. 5. *Octameroceras walkeri* Foerste and Savage. A, living chamber, viewed from above; enlarged 2.2 diameters; B, lateral view, with ventral side on left. From loose boulder at limestone rapids on the Severn river; either from the Ekwan or Attawapiskat limestone. No. 327S in the Royal Ontario Museum of Paleontology.

Fig. 6. *Pentameroceras* (?) *sp.* A, living chamber, ventral view, with hyponomic sinus at top; B, viewed from above, showing aperture with hyponomic sinus on left, dorsal lobe not delineated clearly; C, lateral view, with hyponomic sinus on left, enlarged 2.2 diameters. Limestone rapids on Severn river; either from the Ekwan or Attawapiskat limestone. No. 336S-a in the Royal Ontario Museum of Paleontology.

Fig. 7. *Pentameroceras rarum* Parks. A, lateral view with hyponomic sinus on left; B, view of opposite side, enlarged 2.2 diameters; C, viewed from above, showing aperture with hyponomic sinus at lower edge of figure. Above limestone rapids on Severn river; either in the Ekwan or Attawapiskat limestone. No. 324S in the Royal Ontario Museum of Paleontology.

Fig. 8. *Discosorus parksi* Foerste and Savage. One segment of a siphuncle and part of the overlying segment, viewed from beneath, showing excentric location of septal neck. Assina rapids of Severn river; in the Ekwan limestone. No. 313S in the Royal Ontario Museum of Paleontology. See fig. 3 on pl. VIII; also figs. 3 A, B, C, on pl. XII.

PLATE XXIII

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PLATE XXIV

Fig. 1. *Crateroceras raymondi* Foerste and Savage. A, ventral view, showing very shallow hyponomic sinus; B, lateral view, with ventral side on right. Wauwatosa, Wisconsin; Racine formation. No. 2201 in Museum of Comparative Zoology at Harvard University.

Fig. 2. *Antiplectoceras shamattawaense* (Parks). Lateral view of specimen showing the transverse ribs; sufficient clay has been added to give an idea of the direction of coiling of the conch. Lower rapids of Shamattawa river; in the Shamattawa limestone. No. 325S in the Royal Ontario Museum of Paleontology.

Fig. 3. *Byronoceras longidomum* Foerste and Savage. A, ventral view; B, lateral view, with ventral side on right. Port Byron, Illinois; in Port Byron member of the Niagaran, directly above the Racine. In the U. S. National museum.

Fig. 4. *Chicagooceras welleri* Foerste and Savage. Lateral view, with ventral side on left. Bridgeport, a suburb of Chicago, Illinois; in the Racine. No. 21891 in Walker Museum at Chicago University.

Fig. 5. *Armenoceras hearsti* (Parks). Vertical dorso-ventral section through the siphuncle. Limestone rapids of Severn River; either from Ekwan or Attawapiskat limestone. No. 314S in the Royal Ontario Museum of Paleontology. See also pl. VIII, fig. 4.

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NOTES ON PHYLOGENY IN ERYNNIS SCHR. (THANAOS AUCT.)

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Morphology plays so large a part in the classification of organisms that taxonomy has correctly been called a morphological science. When morphological complexity is multiplied by the occurrence of metamorphosis in the life cycle, as in most insects, the difficulties of classification are proportionately increased, and the results are often uncertain. In more than one case adult insects have been included in the same species by skilled taxonomists, only to be proved distinct by the discovery of their early stages,[1,2] and it is not uncommon to find that conspicuous difference in habits is observed before the accompanying structural distinctions. That structural differences can usually be found in any stage when species are once known to be distinct is merely an evidence of the uncertainty of human observation and interpretation, for often these characters are too insignificant to have been regarded as conclusive without additional evidence.

In the Hesperioidea of North America we find a genus which affords an excellent example. This genus, usually known as *Thanaos*, includes several groups of species which can scarcely be separated by reference to superficial characters alone. As early as 1870 it was found that the genitalia of the males were very different in some of the species which were superficially much alike[3] and the application of the discovery in later years has led to the general understanding that genitalic difference is a necessary basis for the separation of these difficult insects. Un-

[1] Dyar, Psyche viii, 250 (1898).
[2] McDunnough, Can. Ent. lii, 89, pl. ii, f. 2 (1920).
[3] Scudder and Burgess, Proc. Bost. Soc. Nat. Hist. xiii, 282 et. seq. (1870).

fortunately such a conclusion appears to be entirely unwarranted, although we must still recognize genitalic structure as important.

Three of the named species of this genus are *persius* Scudder,[4] *lucilius* Scud. & Burg,[5] and *afranius* Lintner.[6] Scudder and Burgess considered the genitalic structure of the various species known to them and concluded that *lucilius* was distinct from *persius*, corroborating on this basis the conclusion reached by Lintner previously with reference only to superficial characters. I have been unable to verify the differences shown in their figures, for the genitalia are variable in both species. One lepidopterist has gone over the slides in my possession and indicated the presence of both species, but I have excellent reason to believe that only *persius* is represented. Regardless of possible distinctions, it is certain that the genitalia of these two species are close, if not the same, and therefore of no more value than the fairly reliable superficial characters. Scudder and Burgess probably dealt with few dissections, and in small series there is no doubt that differences might be apparent. Lintner, on the other hand, based his description of *afranius* on superficial characters, and that apparently without recognizing its close association with *persius*.

While all three of these forms are closely related, they are sufficiently different from each other to have been treated as species, but it is not surprising that in a genus of such remarkable genitalic divergence they have been lumped together. This step was first taken by Skinner,[7] who considered records of food plants, seasonal occurrence, distribution, superficial characters of the adults, and genitalic structure, and on this basis placed *lucilius*, *afranius* and a third form, *pernigra* Grinnell,[8] as varieties of *persius*. The writer later followed Skinner's treatment, noting superficial differences and mentioning Forbes' opinion that the first named was distinct.[9] It is strange that in neither of these

[4] Proc. Ess. Inst. iii, 170 (1863).
[5] Proc. Bost. Soc. Nat. Hist. xiii, 287, fig. 2 (1870).
[6] Thirtieth Rept. N. Y. State Mus. Nat. Hist. 175 (1877).
[7] Trans. Am. Ent. Soc. xl, 203 et seq. (1914).
[8] Ent. News xvi, 34 (1905).
[9] Iowa Studies in Nat. Hist ix, no. 4, p. 52 (1921).

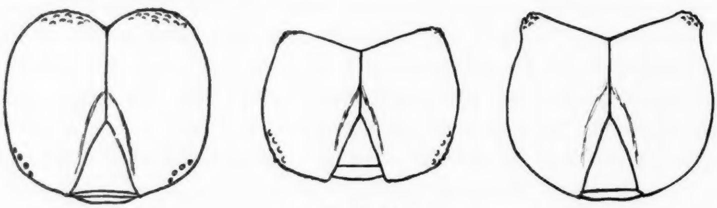
papers is anything said of the larval characters mentioned in Scudder's Butterflies of the Eastern United States. In this work[10] Scudder gives a detailed description of the early stages of both eastern species, *lucilius* and *persius*, exclusive of chaetotaxy, and an excellent account of their life histories. The food plant of the former is said to be *Aquilegia canadensis*, the common columbine, on the authority of several entomologists, including Lintner. Scudder notes, however, that W. H. Edwards claims to have reared it from "pigweed, presumably *Chenopodium album*," in West Virginia. I know of no repetition of Edward's experience, but the species has been reared in recent years from columbine. *Persius*, on the other hand, is recorded by Scudder from *Salicaceae* only, including *Salix humilis* and *Populus balsamifera*, *tremuloides* and *grandidentata*. McDunnough reared specimens from poplar (species?) at Decatur, Ill., but secured only female adults. During the summer of 1925 I secured the third species, *afranius*, in abundance at Almont, Colo., at the junction of the Taylor and East Rivers in Gunnison County, about 8100 feet above sea level. It was easy to observe oviposition, and a considerable number of eggs were taken by searching the food plant, *Lupinus* sp., where it grew in scattered clumps along the irrigating ditches. At higher altitudes, where lupine grew much more luxuriantly, I did not succeed in taking the species. *Pernigra* has not, to my knowledge, yet been reared, and apparently it will be necessary to await knowledge of its early stages to determine its standing.

The different larval habits of these species are in themselves suggestive, but they are, as would be expected, accompanied by morphological differences. In figure 1 will be found rough outlines of the head capsules of the last (fifth) instar of the larva. That of *afranius* was drawn from a series of preserved specimens, while the other two were copied from the more elaborate figures published by Scudder.[11] A comparison of these figures will show at once that *persius* is quite distinct from the other two species, while *lucilius* and *afranius* have certain features in com-

[10] Scudder, Butt. East. U. S. ii, 1458 et seq. and plates (1887).

[11] Op. cit. iii, pl. 80, fig. 35, 41 (1889).

mon. In the first stage the head of *lucilius* is much more distinctly cordate, according to Scudder's figure, than available specimens of *afranius*, while in subsequent stages up to the fifth they are not strikingly dissimilar. In the last instar, as figured, the more quadrate outline of the head of *afranius* will be noted in contrast to the rounded head of *lucilius* with its prominent dorso-lateral projections. The pale areas represented in Scudder's figure are less extensive than in any specimen of *afranius* examined, although the latter species varies greatly in this respect. In one specimen at hand the head is almost entirely buff, with a dark mahogany blotch crossing the front at the apex of the frontal triangle.



a. E. persius *b. E. afranius* *c. E. lucilius*

FIG. 1. OUTLINES OF HEAD CAPSULES OF THE FIFTH LARVAL INSTAR; *a* AND *c*, AFTER SCUDDER, *b*, ORIGINAL

The combined evidence of habits and morphology of the larvae establishes beyond a doubt the specific distinctness of *persius*, *afranius* and *lucilius*. We can only guess about *pernigra* until further information is available. The simplicity of the larval morphology of *persius* suggests that it is the most primitive of the three species, and this, together with what is known of their distribution, would indicate that *persius* is probably nearest to the ancestral form, from which the others my have separated as eastern and western derivatives many years ago. The actual distribution of all three is obscured by the uncertainty of identification, but it seems reasonably certain that *persius* is broadly distributed across the continent, that *lucilius* is found only in the northeastern U. S. and southeastern Canada, and that *afranius* is confined to the mountains of Colorado and more

western states. *To what extent overlapping of ranges occurs* will be very difficult to determine. The fact that closely related representatives of each family of food plants are found in the known range of each species shows that extensive overlapping is at least possible.

Even more interesting than the taxonomic aspects of this case is the evidence of probable courses of evolution which can be drawn from it. The skippers, although primitive in many ways, are not ancient organisms. The only fossils on record, *Pamphilites* Scud. and *Thanaites* Scud., are from the upper Oligocene,[12] so that our modern genera must be relatively recent. Such divergences as these three closely related species in a genus where close relationship is so often accompanied at least by marked difference in genitalic structure suggest extremely recent origin, probably closely correlated with change of food plants. The wide distribution of the three plants concerned, or closely related species of the same families, forces us to attempt to explain how the change might have been brought about. The present definite association of each insect with one or a few related food plants is probably much more stable than the food-plant relationship of the ancestral form, and the vertical distribution of both plants and insects observed in Colorado suggests that temperature adaptations may have played an important part in shaping the ancestral species.

In Gunnison County *afranius* was common at about 8000 to 9000 feet. The Colorado Columbine grew from 9000 feet to above 10,000. A western columbine allied to *A. canadensis* was found only at 10,000 ft. Lupine grew much more luxuriantly in mountain meadows at an altitude of 10,000 feet than at the more arid lower levels, but I was unable to find *afranius* associated with it above 9000 feet. *Populus tremuloides* was abundant from 9000 feet up to the timber line, and narrow leaved cottonwood (*P. angustifolia*?) at lower levels. It seems probable that these nicely correlated food and altitude adaptations may be the outcome of geological changes acting upon the

[12] Handlirsch, Schröder's Handbuch der Entomologie iii, 273 (1921).

primitive ancestral stock, and a consideration of the time following the Oligocene indicates the possibility of several such influences.

Subsequent to the Oligocene there have been no inundations of the North American continent which could account for the separation of a common ancestral stock of general distribution into eastern and western groups, but elevations of significant degree have occurred in the Rocky Mountain region and great glaciers have extended over a large part of the continent. The three families of plants to which the food plants of these insects belong came into existence as early as the Oligocene, hence it is probable that plants bearing some relationship to the modern food plants were available. In considering the possible effects of the geological changes on the association of plant and animal it is necessary to bear in mind the fact that plants must adjust themselves to climatic change by slow adaptation, while animals, in addition to a similar process, may effect a much more rapid adjustment by migration.

A marked elevation of extensive areas in the range of a species would subject the survivors at the increased altitude to unaccustomed extremes of temperature which might be of considerable moment to poikilothermous animals. Migration might easily carry the animal more rapidly into lower levels, where it would find the climatic conditions to which it was adapted, than its food plant could accomplish an equal dispersal, thus forcing a change of food plant upon the organism as a condition of survival. Subsequent gradual dispersal of the newly adapted species would not necessarily disturb its association with the new food plant, with whose dispersal its own might well be correlated.

The advance of an ice sheet might be expected to have a twofold effect, including the southward migration of animals and adaptation to colder climate. The former process might carry a species beyond the range of its food plant, and thus bring about its association with a new food plant as in the case of elevation of the land, while the latter need not necessarily bring about such a change. However those animals which had become adapted to low temperatures in the central part of the continent might

upon the retreat of the ice, either become secondarily adapted to the more temperate climate which would result, or migrate into latitudes or altitudes which would afford congenial climate. It is possible too that a seasonal adjustment might result, accounting for the occurrence of such spring forms as are sometimes found in genera whose species usually fly during the warmer summer season, but such an explanation cannot be applied in the present case. Although purely speculative, it seems not at all improbable that some of these factors may account for the different habits and overlapping distribution of *persius*, *lucilius* and *afranius*.

With a change of food plant once accomplished, we can hardly doubt that an internal adjustment would result which might find expression in the structure of the species. In holometabolic insects the larva, as the stage having direct relationship with this important part of the environment, would be likely to show the greatest, or at least the earliest change, and adult modifications might be expected to follow, rather than to accompany those of the earlier stage. This would account for the appearance of closely related adults with distinctly different larvae, and would emphasize the recency of origin of such species. It would suggest in addition the possibility that many closely related adult insects, whose classification is difficult, if not impossible, might be proved definitely either the same or different by a knowledge of the early stages, and that if such knowledge is also inconclusive, the species concerned is certainly to be regarded as in a state of evolution, variable, but not yet separated into distinct species. In *Erynnis*, at least, we may now be certain that the characters of the adult are not enough to determine the standing of closely related forms.

THE BLUE RIDGE OF SOUTHERN VIRGINIA AND WESTERN NORTH CAROLINA

FRANK J. WRIGHT

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The Blue Ridge from Roanoke, Virginia, to its northern extremity in southern Pennsylvania is a complex mountain of variable width and elevation. In its narrower portions, as at Afton, Virginia, it is essentially a single ridge rising approximately 1200 feet above the Appalachian valley on the northwest and 2000 feet above the Piedmont surface on the southeast. At other places, such as the Luray-Sperryville, Virginia, area, it widens out to ten or twelve miles, and becomes more irregular with sprawling spurs. It is here at least 2000 feet higher than the valley to the west, 2500 feet higher than the Piedmont, and is surmounted by prominent peaks such as Stony Man, 4031 feet, and Hawks Bill, 4065 feet. But on the whole, the Blue Ridge in its northern portion is a single unit, and stands out conspicuously as an irregular mountain ridge with a fairly uniform trend.

In contrast with the ridge-like character of the Blue Ridge north of Roanoke, the southern Blue Ridge is a steep escarpment separating a mountainous upland on the northwest from the Piedmont lower land on the southeast, as seen in Figure 1. The upland in the Hillsville, Virginia region stands 1500 feet above the lowland of the Piedmont, while at Blowing Rock, North Carolina the difference in elevation is 2500 feet. It is the steep Blue Ridge escarpment that separates the upper level of the Older Appalachians on the northwest from the lower level of the Piedmont on the southeast. The section of the southern Blue Ridge extending from Roanoke, Virginia, to Blowing Rock, North Carolina, will be considered in the succeeding pages.

The problem of origin of the Blue Ridge escarpment has re-

ceived brief treatment at the hands of some of the most eminent American physiographers, including Hayes, Campbell, Davis and others. But so far as the writer is aware, no one has considered detailed field evidence in relation to the region as a whole in an effort to trace the history of this striking topographc feature, and to determine the merits of the several theories of

FIG. 1. BLUE RIDGE, WITH ROLLING PIEDMONT ON LEFT AND NARROW STRIP OF UPLAND ON EXTREME RIGHT

Near Piper Gap, Hillsville, Virginia-North Carolina Quadrangle

origin. The present study is based on an extended series of projected profiles, and field work during June, 1924, as well as shorter trips through the area at various times. The escarpment was studied throughout a distance of about one hundred miles.

It is the purpose of the writer to continue field work toward the southwest and to study the Piedmont and Older Appalachians more fully in an effort to decipher the history of the region as a whole. The present report, therefore, is not complete or final, and the conclusions drawn must be regarded as tentative.

The writer wishes to record his profound indebtedness to Professor Douglas Johnson, of Columbia University, for first suggesting the importance of the problem, and for accompanying him on a brief trip through the northern portion of the area in April, 1923. He gratefully acknowledges also the grant of money by the New York Academy of Sciences, which made possible the field expedition.

STATEMENT OF PROBLEM

The Blue Ridge in this region is not a ridge with two distinct slopes. It is an escarpment from 1500 to 2500 feet high, sloping steeply to the southeast. Davis[1] describes this feature in the following words:

> "The divide between the eastern and western streams is known as the Blue Ridge; but in southern Virginia and North Carolina is not a ridge, with a crestline and with well-defined slopes on either side; it is an escarpment (Plate II), descending from the hilly and mountainous upland of the western drainage area to the rolling and hilly lower land of the eastern streams. The cause of this markedly unsymmetrical form is that the eastern streams have worn down their basins to a much lower level than the western streams have. The chief consequence of the unsymmetrical form is that the eastern streams are rapidly—as the earth views time—pushing the escarpment westward. The divide at the crest of the escarpment is, therefore, a migrating divide, with respect to which the eastern streams are gaining drainage area at the expense of the western streams."

From what has preceded, it is obvious that the Blue Ridge is a unique and imposing topographic feature. As a physiographic problem it has unusual interest and importance. In the first place it is noted that the Blue Ridge is called a divide in the above citation. It constitutes indeed a most significant divide between the Atlantic and Gulf drainage in the southern states. With a few local exceptions all streams which rise on the upland west of the escarpment flow to the Gulf, and without exception all those that rise against the escarpment flow to the Atlantic. It is at once one of the simplest and most conspicuous divides in the eastern United States. It extends from Roanoke, Virginia, to northwestern Georgia, a distance of 300 miles.

[1] Davis, W. M. The Stream Contest along the Blue Ridge. Bull. Geog. Soc. Phila., 3, 213–244 (1903).

In the second place, this divide separates streams which are sharply contrasted. Those on the upland to the west have, even in their upper portions, very well graded courses. The eastward flowing streams which drain the escarpment, however, are cutting narrow gorges and occupy typical young valleys. These vigorous streams are gaining ground on the less vigorous streams on the upland which causes a continual westward migration of

FIG. 2. ALMOST PERFECTLY EVEN SURFACE OF PIEDMONT RISING GENTLY TO JOIN THE BLUE RIDGE AT ITS BASE

Looking southwest along scarp from Orchard Gap Road, Hillsville, Virginia-North Carolina Quadrangle.

the divide as explained by Davis. The retreat of the scarp has gone far enough to cause, in some places, important drainage changes, involving the capture of a leisurely flowing stream on the upland by an aggressive young stream heading against the scarp, as shown conclusively by Johnson.[2] The Blue Ridge is, therefore, an excellent example of an unstable or shifting divide.

[2] Johnson, Douglas W. Drainage modification in the Tallulah District. Proc. Bos. Soc. Nat. Hist., 33, 211-248 (1907).

Furthermore, the Blue Ridge separates not only unlike streams but also unlike topographies. The Piedmont on the southeast is, on the whole, an unusually well peneplaned area with only a few monadnocks occurring chiefly along the base of the Blue Ridge. It is a broad, sweeping, moderately dissected surface, cutting into the base of the escarpment, as shown in Figure 2. The upland to the west of the escarpment is more rugged and irregular. There are different degrees of ruggedness in this province. In the Blowing Rock-Grandfather Mountain area, in North Carolina, the general upland level is seen only by close observation because of the numerous monadnock masses above the general upland surface and the extensive valleys carved in this upland. On the other hand, the upland is well preserved with relatively few unreduced monadnocks in the Hillsville-Galax area of Virginia. The former area is probably much more typical of the region as a whole. The Blue Ridge, then, constitutes an important physiographic boundary between the province widely known as the Piedmont on the east and the more rugged upland on the west to which the name of Older Appalachians has been applied.

In the fourth place the Blue Ridge is in the anomalous and unusual position of separating areas which are geologically essentially alike but physiographically unlike. Both areas were parts of the ancient continent of Appalachia and both are composed largely of Pre-Cambrian crystalline rocks, with some Paleozoic sediments, particularly in the Older Appalachians. In both areas there are to be found deeply decayed rocks and a heavy cover of residual soil.

It is the purpose of the writer to attempt to find an adequate explanation of the Blue Ridge as a topographic feature. This will involve a study of the history of the Older Appalachians and the Piedmont, as well as of the escarpment which separates them. This paper is the first of a series on this problem.

THEORIES OF ORIGIN

In order to account for an escarpment which separates an upland from a lowland, it is often necessary to take into con-

sideration the history of the two areas that are separated. Hence several of the theories would solve the problem of the origin of the Blue Ridge by explaining the Older Appalachians above and the Piedmont below. The escarpment is thus indirectly explained as the discordant connection between two areas having had unlike histories.

A. Fault scarp theory. According to this theory the Older Appalachians are the upthrown block and the Piedmont the downthrown block, separated by a fault. It would be well to consider also the possibility of its being a fault-line scarp.

B. Theory of warping. This explanation would account for the Blue Ridge slope as an upwarped zone connecting the Piedmont and Older Appalachian surfaces, which are assumed to have been accordant before warping took place.

C. Marine theory. The marine interpretation makes the Blue Ridge a sea cliff and the Piedmont a marine platform.

D. Theory of two peneplanes of different ages. The Older Appalachian upland surface is conceived to be an older, probably Cretaceous, peneplane, whereas Piedmont represents a later, probably Tertiary peneplane. The Blue Ridge is the discordant divide between the two areas.

E. Theory of two peneplanes of the same age. The streams on the Older Appalachians upland have long courses to the sea, and consequently any peneplane carved by them should stand at a much higher elevation than that developed by the short Atlantic flowing streams on the Piedmont. On the basis of this theory the Blue Ridge is the discordant slope connecting adjacent provinces having had different drainage histories, based primarily on differences in distance to the sea.

F. Theory of superior rock resistance. The Blue Ridge and Older Appalachians according to this interpretation would owe their prominence primarily to the greater resistance of the rocks composing them as compared with the rocks in the Piedmont on the southeast and those of the Appalachian valley on the northwest.

In the following discussion we shall first present the implications of each theory. In each instance there are certain expect-

able topographic features which should appear in the field if the theory is true. These important theoretical requirements will be presented only in summary. There will be references to the literature, where the principles involved are set forth, for the benefit of the reader who may not be familiar with the detailed development of landforms. The second part of the discussion of the theory will deal with the field facts in their definite relationship to the theoretical requirements. In other words, an attempt will be made to determine whether the topographic features required under the theory do actually exist. Finally, the adverse field evidence will be recited and the theory considered in relation to the general history of the two physiographic provinces.

FAULT SCARP THEORY

If the Blue Ridge escarpment is to be explained on the basis of profound faulting, there are certain features which ought to appear in the subsequent development of the landform. Davis[3] has given a clear exposition of the features of block mountains. The criteria of block faulting will be stated briefly.

1. Simple base-line. It is a matter of common knowledge that upfaulted blocks of the earth's crust are normally bounded by simple base-lines. They may be straight or curved, but they are not irregular or sawtooth.

2. Base-line independent of rock structure. Ordinarily the fault cuts across the structure of the rock and frequently exhibits different rock types in the scarp.

3. Two unequal slopes. The transverse profiles of block mountains normally have two slopes of which the fault scarp is usually the steeper.

4. Short parallel consequent streams flowing down the scarp and developing a series of parallel narrow valleys, all of which open out along a line into the broad open lowland of the depressed block. These transverse valleys are quite out of keeping in their character and stage of development with the broad lowland into which they enter.

[3] Davis, W. M. Geographical Essays, pp. 725–772.

5. Series of parallel spurs carved out of the scarp, which terminate approximately in a line marking the initial position of the scarp. These spurs are transverse to the trend of the scarp.

6. The spurs referred to above are frequently terminated in the earlier stages of their development by triangular facets representing remnants of the fault surface.

7. Displacement in the rock series. This is a purely geological line of evidence, but it may be used to supplement the physiographic.

There are few if any, block mountains which exhibit all of the features mentioned above, some of which are obviously more convincing than others. Nevertheless they are the leading criteria for the recognition of this type of landform.

FIELD EVIDENCE ON THE FAULT THEORY

1. Simple base-line. The base of the Blue Ridge has an elevation of approximately 1500 feet above sea level throughout the portion of the mountain that has been studied. The crestline varies in altitude between 3000 and 4000 feet, and the height of the escarpment is between 1500 and 2500 feet. The degree of simplicity of base-line is determined primarily by means of map study, supported by field photographs and visual impressions. The writer has traced the baseline following the 1500 foot contour, and crestline, beginning with the Hillsville, Virginia-North Carolina, quadrangle and extending through Mt. Mitchell, North Carolina, quadrangle, a distance of approximately 150 miles. This tracing shows many irregularities in the trend of the base-line, apparently too numerous to suggest block faulting, even after due allowance has been made for the effects of erosion. The irregularities are greatly minimized when map is reduced to a small scale, as in Plate XXV.

An extensive series of projected profiles covering strips of country four miles wide and spaced four miles apart, was constructed across the Blue Ridge. The vertical exaggeration was approximately ten. The profiles were then set up and photographed. When one looks along the escarpment the deeply indented character of the base-line is very apparent, as may be

seen in Plate XXVI. At many places the view along the escarpment shows numerous ridges and spurs with valleys between them setting back into the upland, as seen in Figure 3.

2. Base-line independent of rock structure. From an examination of the geologic maps and sections contained in the Cranberry, North Carolina-Tennessee, Mount Mitchell, North Carolina-Tennessee, and Pisgah, North Carolina-South Carolina

FIG. 3. BLUE RIDGE ON RIGHT WITH IRREGULAR SPURS RUNNING OFF TOWARD LEFT

Near Low Gap, Hillsville, Virginia-North Carolina Quadrangle

Folios of the U. S. Geological Survey, it is apparent that the present base-line of the Blue Ridge does not conform in a close way to any structural condition of the rock. This deduction from the map is corroborated by field observation. In view of the fact that the Blue Ridge is steadily retreating westward under the influence of vigorous cutting by the streams on the east, it is necessary to take into consideration the possibility of a parallelism between the scarp and the underlying rock structure in the area

somewhat to the east of the present position of the Ridge where the supposed faulting may have taken place. This is believed to be unlikely in view of the fact that the retreat of the scarp could not have been many miles, and rock structures seem to be uniform for a considerable distance toward the east.

While the scarp does not coincide with either lines of faulting or belts of rock distribution, it is nevertheless true that the Blue Ridge trends northeast and southwest, and the general trend of rock structures, including folds, faults, and schistosity, is in the same general direction. The direction of strike of these structures is variable and the rock formations are not usually in distinctly parallel belts. The course of the Blue Ridge is even more irregular, and in exceptional cases cuts across the rock structures at an angle of nearly 90 degrees, as for instance in the Blowing Rock district.

It would seem safe to conclude that the base-line of the Blue Ridge, while in general conformity with the major rock structures of the area, appears to be entirely independent of the local structures in the districts covered by the folios.

3. Two unequal slopes. It is not difficult to get a clear idea of the slopes of the mountain from a study of some of the projected profiles which the writer has made from the topographic maps. Unfortunately, this criteron is not very convincing because unequal slopes occur frequently where faulting has not taken place. Those from the northeastern portion of the area in Virginia show very clearly two unequal slopes, while those from the southwestern section give little or no suggestion of such expectable slopes. This evidence points to the possibility of a fault origin for the northern section, but throws no light on the origin of the southern portion of the scarp. Furthermore, it should be pointed out that the northern section, with obviously unequal slopes, represents only a small part of the total length of the Blue Ridge escarpment.

4. Short parallel consequent streams flowing down the scarp. The nature of the valleys developed along the scarp is shown by the crenulations of the 1500-foot contour line marking its base (see Plate XXV). The irregularity of arrangement and di-

rection of flow are very striking. Block mountains are fairly uniform in showing a general parallelism and regularity of distribution of streams on their scarps, whereas the Blue Ridge streams are very different in these respects. This line of evidence is distinctly opposed to the theory of fault origin.

5. Series of short parallel spurs dissected out of the scarp and terminating approximately in a line marking the former position of the fault surface.

There are numerous short spurs which slope down from the scarp and disappear near its base. These features are extremely irregular in arrangement and trend, as shown in Plate XXV. In many cases there is a distinctly radial pattern in which smaller spurs are grouped around the more massive ones. There is almost no suggestion of parallelism of spurs in the 150 miles of scarp visited in the field. The map representations are precisely in accord with numerous field observations made throughout the area. The spurs may be described as sprawling. Davis,[4] referring to this portion of the Blue Ridge, says

> "Viewed in a very general way, as on a small scale map, the base of the scarp is of moderate curvature, and its slope is essentially independent of structure; hence in both these general features it might be said to resemble the face of a Basin range. But when viewed in detail, the base of the escarpment is sinuous in a high degree, with numerous branching spurs that advance between well-carved amphitheaters; the spurs gradually fade out forward instead of being abruptly terminated at a well-defined base-line, as is so persistently the case with the above described ranges of Utah and Nevada. In some cases the spurs run far forward, forming ridges of undulating outline, by which embayments of the piedmont lowland are divided."

There is another class of spur-like features associated with the Blue Ridge that should be considered in this connection. There are only two representatives in this region, Brushy Mountain and South Mountain. The former rises near Lenoir on the Morganton, North Carolina, quadrangle, extends about 45 miles northeastward, and terminates in Fox Knob, Yadkinville, quadrangle. In its higher portions the ridge attains elevations of 2500 to 2600 feet, and a width of five to eight miles. Its south-

[4] Davis, W. M. Geographical Essays. Mountains of the Great Basin, 738.

western end is approximately eight miles east of the base of the Blue Ridge, but the range is, however, less detached from the Blue Ridge than would appear from the above description. A less imposing ridge, which may be called the Jerry mountain range, stands between Brushy Mountain and the Blue Ridge and very close to the former. On the southwest it is practically connected with South Mountain and only two miles from the base of the Blue Ridge. For general purposes one may regard the Jerry Mountain and Brushy Mountain ranges as a single feature, separated at its southwestern end by a distance of several miles from the Blue Ridge mass.

The second irregular feature associated with the Blue Ridge scarp is the South Mountain range situated chiefly on the Morganton quadrangle. It has an average width of about eight miles and a maximum elevation of 2850 ft. Both of these spurs may be seen in the profile view, Plate XXVI. Brushy Mountain is the more obvious, although farther away, in the middle ground of the illustration.

It will thus be seen that there are in this region several large features which almost join the Blue Ridge on the southwest, but diverge farther and farther from the scarp by reason of their more easterly trend. Let us consider the possible lines of explanation of these features on the basis of a fault origin for the Blue Ridge. Since they are bordered both on the northwest and southeast by typical piedmont topography in which the peneplane surface is the outstanding element, it might be possible to explain them as fault splinters, or as horsts between grabens. Among the obvious objections to this explanation is the distinct separation of these spurs from the main mass of the Blue Ridge, without topographic evidence of cross-faulting, which would be required for such a separation; the irregular and indented baselines of the ranges; and the irregular stream and spur patterns. An alternative theory would be to regard them as unreduced erosion remnants standing on the original peneplane surface before faulting took place. This would require the existence of ridge-like topographic features rising approximately a thousand feet above the level of the upland peneplane. If this be true,

their southwestern continuations might be expected to exist to-day on the older Appalachian upland. Apparently no such features exist.

Finally, if these features can not be consistently referred to the original surface before faulting took place, and if they were not produced as splinters or horsts during faulting, they must have been developed through erosion after the period of faulting. On the basis of an erosional interpretation we must conclude that they were dissected entirely from one block or the other. They must have been carved either from the Older Appalachian mass or the Piedmont block. This is a necessary conclusion because a fault of proportions large enough to account for the Blue Ridge could not have cut through these ridge-like spurs without topographic expression.

If now the spurs must be assigned wholly to one block or the other, we have certain limitations as to the possible position of the fault plane. It must be either between the southwestern ends of these spurs and the Blue Ridge, or in the Piedmont beyond their northeastern ends.

If the faulting took place in the narrow zone a mile or two in width between the spurs and the Ridge, it is obvious that there could have been since the time of faulting only a slight westward retreat of the scarp such as Davis has shown to be taking place at the present time. With the fault in this position the spurs must have been carved from the Piedmont block. Prongs of the Piedmont peneplane surface are splendidly developed for a considerable distance behind these spurs, which stand about a thousand feet, on the average, above the Piedmont. It must have required the greater part of a long geographical cycle to develop this peneplane surface. It is unlikely, in view of its constant migration, that the Blue Ridge would have retreated so little during so long a period of erosion.

In case the faulting took place beyond the eastern ends of these spurs they must have been developed out of the Older Appalachian block. This would permit a retreat of the scarp of at least 15 miles in the case of Brushy Mountain, and about 20 miles in the case of South Mountain. This is surely enough to

meet the objections raised in the above paragraph. The spurs, however, do not terminate even approximately in a line, and give no suggestion of a former position of the fault. There is no other topographic or drainage evidence in its support. Furthermore, one would expect to find these spurs becoming increasingly massive and finally uniting with the Blue Ridge. Instead, as previously pointed out, their central parts are the highest and most

FIG. 4. BLUE RIDGE WALL, AS SEEN FROM PIEDMONT
Near Mt. Airy, North Carolina

massive, and they are entirely disconnected from the Blue Ridge. The existence of these ridges or spurs in front of the Blue Ridge is a fact that is extremely difficult of explanation on the basis of the fault theory.

6. Triangular facets. One of the commonly observed features exhibited by block mountains during the early stages of their dissection is the triangular facet. Neither the topographic maps nor the field studies give any suggestion of the presence of such features pointing to the former existence of a fault surface along

the Blue Ridge front. A representative view of the scarp is shown in Figure 4.

7. Stratigraphic displacement. The rocks of the region include representatives of the three major groups of igneous, sedimentary and metamorphic rocks. Furthermore, they are folded and faulted. We have, fortunately, the Cranberry[5] and Mt. Mitchell[6] folios which cover parts of the scarp in the area being considered, and the Pisgah folio[7] which touches the Mt. Mitchell area at its southwestern corner. According to Keith, author of the folios, faults are very rare in the Pisgah area and seem never to have any relation to the Blue Ridge scarp. In the other quadrangles toward the northeast faults are very much more numerous. They do not, however, show any relationship to the scarp, which is apparently quite independent of them. Furthermore, most of the faults are thrusts from the southeast. The supposed fault scarp would have to face westward.

The testimony of the three folios is quite clearly against faulting as an important factor in the origin of the Blue Ridge.

By way of summary, it may be said that of the seven lines of evidence considered, only two are favorable to the fault theory; base-line independent of rock structure, and the presence of two unequal slopes. It was pointed out above that the latter is at best never more than a mildly suggestive line of evidence and is shown in only a small section of the scarp, and the former, while considerably more valuable, is not in itself conclusive.

The five remaining lines of evidence discredit the proposed theory. The base-line is not simple; there are no short parallel consequent streams draining the scarp; spurs dissected out of the scarp are not parallel and of approximately the same length; triangular facets are wanting; the stratigraphic evidence does not show adequate faulting. In view of the greater reliability of each of these criteria as compared with the preceding group the writer is of the opinion that it is safe to conclude that the Blue Ridge cannot be correctly explained as a fault scarp.

[5] Keith, Arthur. U. S. Geol. Surv. Folio 90 (1903).
[6] Keith, Arthur. U. S. Geol. Surv. Folio 124 (1905).
[7] Keith, Arthur. U. S. Geol. Surv. Folio 147 (1907).

As a corollary of the fault scarp theory, it would be wise to consider the possibility of its being a fault-line scarp.[8] Fault-line scarps are developed through long erosion along a fault line. They are most apt to appear in a second or later cycle. Both resequent and obsequent types are recognized. The resequent fault-line scarp faces in the same direction as the original fault scarp while the obsequent scarp faces in the opposite direction.

It is not probable that the Blue Ridge is an obsequent fault-line scarp, for this would require a northwestward slope for the original fault scarp. Under this theory there would have been a westward flowing series of consequent streams draining the scarp of the upthrown eastern block. They would have pushed the divide eastward until a considerable area of what is now Piedmont would have been under the influence of westward flowing drainage. This condition must have obtained until the rocks now composing the Blue Ridge were exposed to erosion. Then by reason of weaker rocks on the southeast the drainage must have been gradually shifted to a southeasterly direction. We should hardly expect to have so complete a reversal of drainage over so large an area without any trace of a record in the present drainage.

The resequent fault-line scarp would probably fit the facts better. One of the obvious difficulties in the application of the fault-line theory is the implication of very superior resistance of the rocks composing the Blue Ridge. It is doubtless true that superior rock resistance is a factor in accounting for the Blue Ridge, but it is probably not the most important factor. The rocks composing the Blue Ridge and Piedmont are so nearly alike that the sharp contrast in resistance demanded by the fault-line scarp theory is a condition difficult if not impossible to meet.

The intricate pattern of the base-line already discussed is equally opposed to the fault-line theory. In like manner the remaining difficulties in the way of a fault explanation stand to a greater or less degree opposed to the fault-line interpretation.

There is another line of evidence which, although in itself far

[8] Pirsson and Schuchert, Textbook of Geology, Part 1, 369 (1920).

from conclusive, at least throws doubt upon the applicability of the fault theory. If the Blue Ridge is of fault origin, there would be two initial slopes, the one to the east or southeast, the other to the west or northwest. The consequent streams on the southeast have already been considered. Those on the northwest would be, presumably though not necessarily, flowing on a gentler slope. Their courses then would probably not be quite as straight as those on the scarp, but their general arrangement should be in roughly parallel lines, opposite in direction to those on the scarp. This condition is well illustrated on the gentle western slope of the Sierra Nevada mountains.

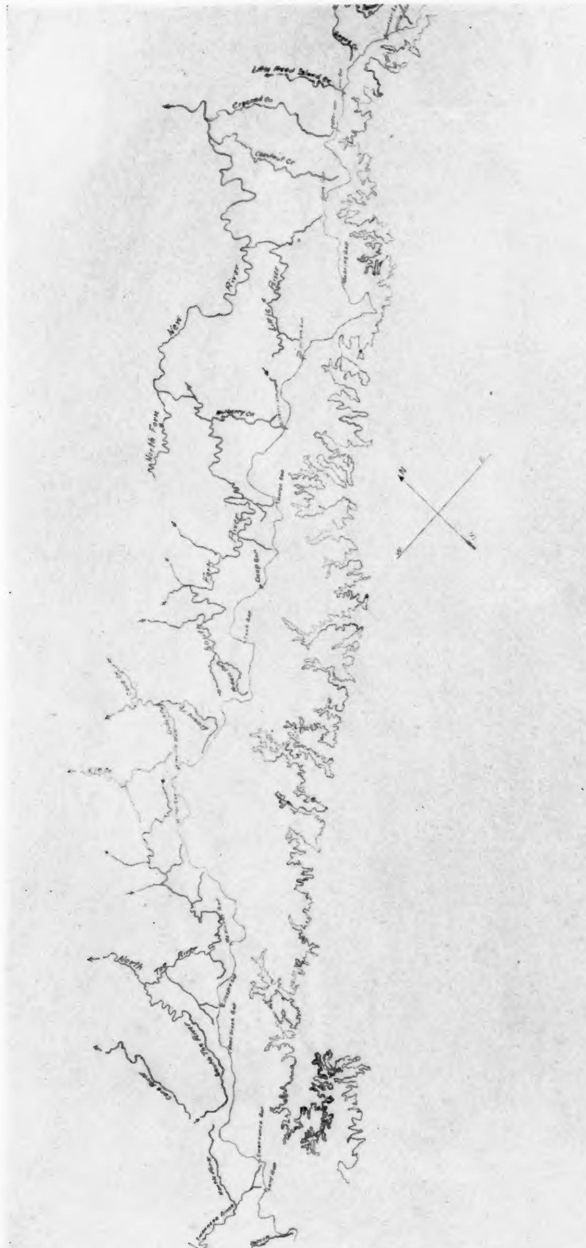
The major streams on the upland which take their courses near the scarp are indicated in Plate XXV. There are some lines which follow a direct northwesterly course, but there are several conspicuous exceptions. The New River, for a distance of more than fifty miles flows along on the upland nearly parallel to the scarp at distances varying from two to fifteen miles. The North Toe River parallels the scarp for about twenty miles at distances of two to four miles west of the scarp. It is almost impossible to explain the courses of these streams on the theory of fault origin for the Blue Ridge unless it be regarded as an obsequent fault-line scarp.

It is, therefore, the belief of the writer that faulting need not be seriously considered as a factor in the history of the Blue Ridge of southern Virginia and western North Carolina. Other theories will be presented in subsequent issues of this Journal.

PLATE XXV

Blue Ridge Escarpment

Base-line indicated by crenulated line representing 1500′ contour. Crestline follows drainage divide, and varies between 3000′ and 4000′. Hillsville, Virginia Quadrangle, to Mount Mitchell, North Carolina Quadrangle, a distance of about 150 miles. Scale approximately 20 miles to the inch.

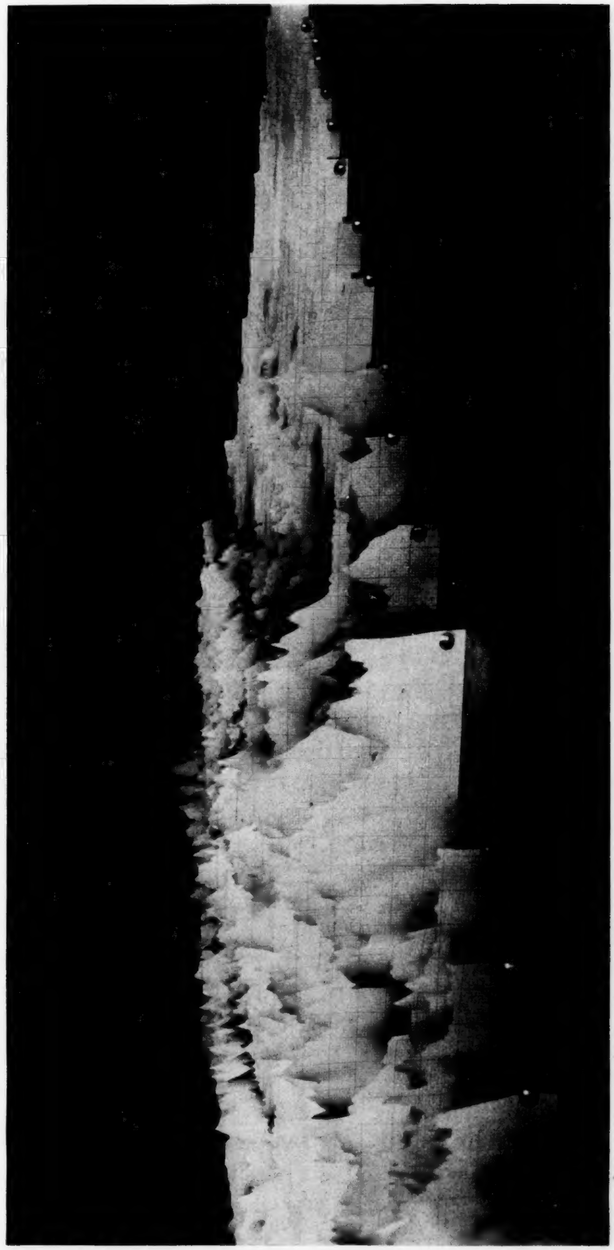


FRANK J. WRIGHT BLUE RIDGE OF VIRGINIA AND NORTH CAROLINA

PLATE XXVI

Profile View Looking Northeast, Showing Piedmont on Right and Older Appalachians in Center

Note the irregular base-line of the Blue Ridge



FRANK J. WRIGHT BLUE RIDGE OF VIRGINIA AND NORTH CAROLINA

GRAVELS ON THE BLUE RIDGE

FRANK J. WRIGHT

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While engaged in field investigations in the Southern Appalachians during the month of June 1924, on a grant from the research funds of the New York Academy of Sciences, the writer noted rounded gravels on the surface of the Older Appalachian upland in southern Virginia. The Blue Ridge from Roanoke, Virginia, to northwestern Georgia is merely the southeastern escarpment of an elevated mountainous upland standing from three to four thousand feet above sea level and surmounted by peaks rising several thousand feet higher. It is the steep slope leading down from this upland (3000 to 4000 ft.) on the northwest to the Piedmont (1500 ft.) on the southeast.

The gravels and boulders are composed of quartz and quartzose material and range in size from several inches up to a foot or more in diameter. Their shapes are highly variable. Some are well rounded on three or four sides and a few on all sides. They differ markedly from those found in the valleys of present streams and even from those on the surface of the Piedmont peneplane, as well as from those on the valley peneplane of the Newer Appalachians. In the latter occurrences, so far as the writer has observed them, the gravels are well rounded on nearly all sides, but frequently deeply pitted due to weathering following rounding. Modern gravels show rounded shapes without noticeable pitting. The Blue Ridge gravels, however, are ordinarily not well rounded on all sides but frequently have some angular or sub-angular faces indicating broken surfaces. Pitting is shown on some, and disintegration in many cases has caused the splitting off of fragments which if replaced would restore a well rounded form. In others, structure lines have been opened by weathering since rounding. The general nature of the curved surfaces indicates

rounding followed by long exposure to weathering which in some cases has almost obliterated the former shape. It would appear that these gravels are in a more advanced stage of weathering than the Tertiary (?) gravels on the divides of the Piedmont and Appalachian valley.

Gravels were observed at a half dozen different localities chiefly on the Hillsville, Virginia, quadrangle. With one exception all are on the upland a short distance west of the scarp. The writer

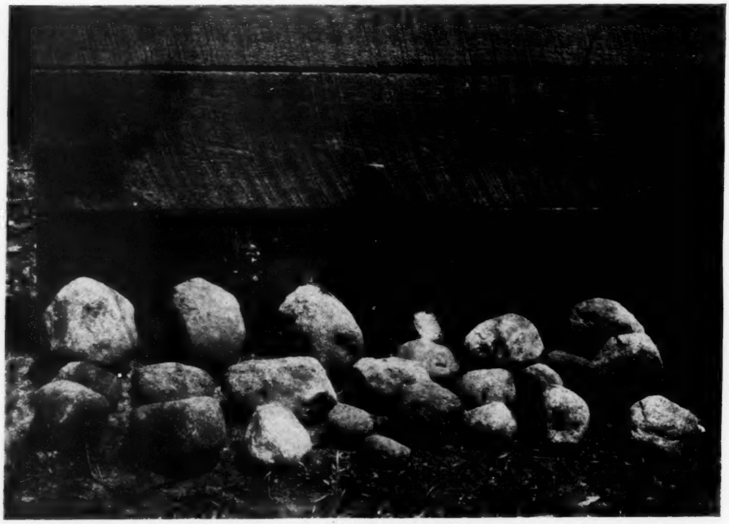

FIG. 1. ROUNDED BOULDERS ON SURFACE OF OLDER APPALACHIANS NEAR HILLSVILLE, VIRGINIA

made no intensive search over the area and there are doubtless many occurrences which escaped his notice. Gravels were found at various points along the scarp between Willis Gap (Hillsville, Virginia-North Carolina, quadrangle) and Roaring Gap (Yadkinville, North Carolina, quadrangle).

A group of small boulders ranging in diameter from two up to six or eight inches was collected along the highway nine miles southwest of Hillsville, Fig. 1. The elevation at this point is

approximately 2700 feet, or probably 100 feet below the upland Cretaceous (?) peneplane, which is extremely well developed in this area. About two and one-half miles southwest of Fancy Gap deeply weathered boulders up to a foot in diameter were found at an elevation of 3100 feet, not more then forty feet below the level of the Blue Ridge escarpment which here forms the Atlantic-Mississippi divide. They were chiefly on the northwest slope, but one was actually on the divide. About one mile east of Willis Gap, at the Bluemont Presbyterian Church, they were found in quantity on the divide at an elevation of more than 3000 feet. They showed every sign of old age, pitting, shelling off and opening of structure lines. Some have been broken since rounding, giving angular faces on one or two sides with splendid rounding on remaining sides.

The most plausible theories of origin are that they represent either boulders of disintegration or water-worn materials. Their degree of rounding, not due to spheroidal weathering, and their dissimilarity to the bed rock, at least in some places, would seem to discredit the former interpretation. Their composition, degree of rounding and dissimilarity to the underlying rock would be entirely consistent with either the theory of stream or marine origin. The gravels themselves do not enable us to discriminate between these two suggestions, but what is known of the early history of the Appalachians is unfavorable to the marine interpretation. The nature of their distribution, especially in reference to ancient drainage lines, if these could be restored, might possibly throw additional light on their origin.

In view of the fact that the gravels are found to-day on slopes that are only slightly below the upland (Cretaceous?) peneplane it seems likely that they are related in origin to this surface. They may have been worn by the streams of this early cycle or by streams in the very early part of the next (Tertiary) cycle.

In the light of the above facts these gravels may be Cretaceous in age, and if so perhaps the oldest stream gravels remaining on a peneplane surface that have been reported in the Appalachians.

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NOTE: In accordance with a ruling of the postal authorities it has become necessary to change the name of this publication from "BULLETIN" to "JOURNAL" of the SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.